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Safety Standards for Self-Propelled Vessels Carrying Bulk Liquefied Gases; Special Interim Regulations for Issuance of Letters of Compliance to Barges and Existing Liquefied Gas Vessels

DEPARTMENT OF TRANSPORTATION

Coast Guard

46 CFR Parts 31, 34, 40, 54, 56, 98, 154, and 154a

Safety Standards for Self-Propelled Vessels Carrying Bulk Liquefied Gases; Special Interim Regulations for Issuance of Letters of Compliance to Barges and Existing Liquefied Gas Vessels

AGENCY: Coast Guard, DOT.

ACTION: Final Rule.

SUMMARY: This amendment revises construction, equipment, safety and operating requirements for all new vessels carrying liquefied gases in bulk on the navigable waters of the United States. Due to the increasing amounts of liquefied gases being shipped in bulk, and the potential hazard these cargoes present, the Coast Guard determined that more detailed rules governing their carriage were necessary to maintain a high degree of safety to both life and property.

EFFECTIVE DATE: This amendment is effective on May 31, 1979.

FOR FURTHER INFORMATION CONTACT: Dr. Anthony L. Rowek, Office of Merchant Marine Safety (G–MHM–1/83), Room 8309, Department of Transportation, NASSIF Building, 400 Seventh Street, S.W., Washington, D.C. 20590 (202–426–1217)

SUPPLEMENTARY INFORMATION: On October 4, 1976, the Coast Guard published a proposal in the **Federal Register** (41 FR 43822) to revise the regulations governing new self-propelled vessels carrying liquefied gases in bulk. The proposal would adopt all but four recommendations contained in the Inter-Governmental Maritime Consultative Organization's (IMCO) *Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk,* Resolution A.328(IX), adopted without amendments November 1975 (IMCO Gas Code). The four areas in which this rule is more stringent than the IMCO Gas Code are:

1. The specification of design ambient temperatures;

2. Requiring enhanced grades of steel for crack arresting purposes in the deck stringer, sheer strake and bilge strake;

3. Specification of higher allowable stress factors for independent tanks type B and C; and

4. Prohibiting the use of cargo venting as a means of cargo pressure/temperature control.

Interested persons were given an opportunity to submit written comments to the Coast Guard concerning the proposal until December 15, 1976. A public hearing was held in Washington, D.C. on 15 November 1976. A discussion of comments received is contained in the following paragraphs.

DRAFTING INFORMATION: The principal persons involved in the drafting of this rule are: LCDR T. R. Dickey and Dr. A. L. Rowek, Project Managers, Officer of Merchant Marine Safety, and Mr. Stanley M. Colby, Project Attorney, Officer of Chief Council.

Discussion of Comments

Miscellaneous

The authority for the proposal was derived from 46 USC 170, except for flammable and combustible liquid cargoes for which the authority is derived from 46 USC 391a. Since the proposal was published, the Port and Tanker Safety Act of 1978 (Pub. L. 95–474, 92 Stat 1471, October 17, 1978) has been enacted. This new Act allows the Coast Guard to regulate flammable liquids and solids, combustible liquids and solids, poisons, oxidizing or corrosive materials, and compressed gases. Since there is no longer any need to cite 46 USC 170 for part of the authority, the authority citation has been changed.

Several commenters requested that, in addition to the table cross-referencing the requirements of Part 154 with the IMCO Gas Code, a table be provided cross-referencing the IMCO Gas Code to Part 154. The Coast Guard has developed the additional cross-reference list but has not published it with this rule due to its length and similarity with the cross-reference list in the preamble to the proposed rule. These tables will be published in a future Navigation and Vessel Inspection Circular.

One commenter questioned how liquefied gasses not listed on Table 4 may be shipped in bulk. When a shipper or carrier asks to ship a liquefied gas that is not included in Table 4, he must first notify the Coast Guard of his intention to transport the cargo, and submit a data sheet showing the chemical and physical properties of the product. Coast Guard form CG–4355 is available from local Marine Safety Offices for this purpose. After the Commandant (G–MHM) has evaluated the hazards of the product, and determined that it may be safely carried in bulk on ships, the appropriate requirements will be developed and the interested persons notified. A new section has been added at § 154.12 to include these considerations.

To incorporate present Coast Guard requirements for a Letter of Compliance into these proposed regulations, the portions of existing 46 CFR Part 154, "Special Interim Regulations for Issuance of Letters of Compliance," that applied to new liquefied gas carriers have been added to proposed Part 154. The sections added generally deal with the administrative requirements for obtaining a Letter of Compliance and describe the procedure which the owner of a foreign flag vessel must follow to arrange for the Coast Guard to examine his vessel. To incorporate this information the following changes and additions were made to proposed Part 154:

(1) Add a new section, § 154.150, entitled, "Examination for a Letter of Compliance."

(2) Add a new section, § 154.151, entitled, "Scheduling a Letter of Compliance examination."

(3) Add a new section, § 154.152, entitled, "Notification of arrival for a Letter of Compliance examination."

(4) Add a new section, § 154.153, entitled, "Carrying cargo into U.S. waters for a Letter of Compliance examination."

(5) Change proposed § 154.1802 to require either a Letter of Compliance or written authorization by the Commandant (G–MHM) for a foreign flag vessel to operate in U.S. waters.

(6) Add a new section, § 154.1803, entitled, "Expiration of Letters of Compliance".

The Coast Guard will continue to perform the "Concept approval" review service, a pre-construction Coast Guard-Industry design consultation, for all new cargo containment designs for vessels of U.S. registry or foreign flag registry intended for trade in the U.S. However, with the publication of this rule, the procedure for the "concept approval" review service is modified. If the Coast Guard determines that the proposed containment system meets section 4.2 of the IMCO Gas Code, no further "concept approval" review will be performed. For U.S. flag vessels, this is done by the Coast Guard prior to conducting full ship plan review. For new or novel designs which do not meet section 4.2 of the IMCO Gas Code, the "concept approval" review procedures will remain unchanged.

Comments of a general nature, usually critical of the Coast Guard's proposal having exceeded the IMCO Gas Code, were received. Many of these comments offered no specific details where the proposal exceeded the Code's

recommendations. Some claimed that, taken together, these additions would make U.S. flag vessels more expensive to construct and would put the U.S. flag vessel owner at an economic disadvantage. One commenter also noted that if the Coast Guard's economic assessment of the impact of the proposal were based on the Code's requirements, the assessment should be reconsidered.

Where specific comments were received that indicated that the Coast Guard had exceeded the Code, they have been addressed in this preamble. As explained in the preamble to the notice of proposed rulemaking, there are four areas where the Coast Guard intended to exceed the Code. These requirements are applicable to foreign flag vessels as well as U.S. flag vessels. Further, they have been standards adhered to in the U.S. for some time now, therefore, they neither put the U.S. flag vessel at a disadvantage, nor do they increase the cost of the vessel over current costs.

As also explained in the preamble of the notice, specific details have been added to the Code's rather general language in many instances. This is necessary in order to give designers, builders, and operators definitive guidelines as to what the Coast Guard will accept. Administrations of other nations will undoubtedly have to do the same. Being more specific may be viewed by some as "exceeding the Code" but using the sometimes vague language of the Code would require designers and builders to constantly approach the Coast Guard for interpretations. While that will still be inevitable in some cases, the regulations have been written to minimize those occurrences.

To assess the economic impact of specific design requirements versus a general design goal is difficult, if not impossible. For instance, if the Code required that filling lines extend to "near the bottom of the tank" and Coast Guard regulations required the line to terminate 100 mm (4 inches) from the bottom, how can the cost difference, if any, be assessed? The Coast Guard did revise many requirements where the proposal exceeded the Code unintentionally. In other instances, more liberal, satisfactory interpretations of the Code's requirements allowed relaxation of the proposal. The Coast Guard has attempted to hold instances of implied "exceeding the Code" to an absolute minimum, consistent with the goal of providing definitive guidelines wherever possible.

For the reasons outlined above, the Coast Guard cannot accept the argument that the regulations will make the U.S. flag ship non-competitive, nor that the economic impact of the regulation is significantly different than previously determined.

Finally, numerous editorial changes and corrections have been made to the proposal. Where the Coast Guard determined that these corrections were important, they have been explained, however, due to space limitations other routine or unimportant editorial changes have not.

Amendments to Subchapters D, F, and I

Section 31.10–18a. One commenter suggested that for several of the operating requirements in proposed § 31.10–18a, the master should not be held responsible for ensuring that certain procedures are carried out, but that the responsibility should be placed on "the master or duly appointed company representative." It is traditional and reasonable that the master of the vessel is ultimately responsible for the safety of his ship and crew. Therefore, the suggestion was rejected and the requirements remain as proposed.

Section 54.15–25. One commenter said that in proposed § 54.15–25(c) the formulae used to calculate the gas factor, G, in metric units and English units are not equivalent. The constant in each formula for G consists of the assumed heat flux into the cargo tank plus conversion factors which yield flow capacity in volume flow of dry air at standard temperature and pressure. Assumed standard conditions in metric units are P=1 atm. and T=0°C, while in English units they are P=14.7 psia(1 atm) and T=60°F (15.6°C). The difference in assumed standard temperature produces the slight difference in calculated flow. To convert Q calculated in one set of units to the other units, multiply Q by the square root of the ratio of the standard temperatures after applying the usual conversion factors for volume. The formulae for G are correct as proposed and no change has been made.

Section 54.25–10. Three commenters pointed out errors in the chemical composition limits for carbon manganese steel in proposed § 54.25–10. Sulfur and phosphorus limits have been changed from "0.35" to "0.035".

Subpart 98.25. In the amendments to existing regulations which were proposed, Subpart 98.25 of this chapter, entitled "Anhydrous Ammonia in Bulk", was revoked. This was incorrect. The applicability of Subpart 98.25 is to all ships carrying anhydrous ammonia. Proposed Part 154 includes requirements for the carriage of anhydrous ammonia only on new ships, i.e. those meeting proposed § 154.1. Subpart 98.25 as it applies to *existing* anyhydrous ammonia ships must therefore be retained. This subpart has been retained and § 98.25–1 rewritten to include the correct applicability.

General

Section 154.1. One commenter pointed out that the proposed regulations and the IMCO Gas Code apply to steel-hulled ships, but do not specifically state this. He further suggests that this consideration be included in the proposed applicability section. The Coast Guard does not consider this necessary. These proposed regulations and the IMCO Gas Code were developed to cover all liquefied gas vessels. The requirements in proposed § 154.170, which establishes acceptable standards for the outer hull materials, address only steel because steel is considered to be the standard construction material. It is noted, however, that a vessel with a hull constructed of materials other than steel would be handled under the equivalency provisions of § 154.8. Due to these considerations this suggestion was not accepted.

Several commenters raised questions regarding existing ships, i.e., those ships not included in the proposed Applicability section § 154.1. Existing foreign flag liquefied gas vessels are now regulated by 46 CFR Part 154, "Special Interim Regulations for Issuance of a Letter of Compliance," while existing U.S. flag vessels are regulated by Subchapter D, 46 CFR Parts 30–40, "Tank Vessels," and Subchapter I, 46 CFR Parts 90–109, "Cargo and Miscellaneous Vessels." Existing gas ships will continue to be regulated under these parts until the publication of more detailed rules covering these vessels. With the publication of new Part 154, the "Special Interim Regulations . . .", previously published as Part 154, have been redesignated Part 154a.

When originally published, the "Special Interim Regulations . . ." covered the carriage of both bulk liquid chemicals and liquefied gases on new or existing foreign flag ships and barges. With the publication of Part 154 and Part 153 (42 FR 49016), regulation of *new* liquefied gas ships and *new or existing* bulk liquid chemcial carriers has been transferred from the "Special Interim Regulations . . ." to these parts. Accordingly, after these editorial changes, the "Special Interim

Regulations . . ."now cover only foreign flag barges and existing gas ships.

To invite public participation in the rulemaking for "existing" liquefied gas vessels at an early stage, an advance notice of proposed rulemaking entitled "Construction and Equipment of Existing Self-Propelled Vessels Carrying Bulk Liquefied Gases," was published in the June 30, 1977 issue of the Federal Register (42 FR 33353). Briefly these new rules will follow present U.S. requirements and those substantive requirements of the "IMCO Code for Existing Ships carrying Liquefied Gases in Bulk", adopted October 1976, that exceed current U.S. standards in 46 CFR Subchapters D, F, I, and J. These rules should be similar in structure and content to new Part 154 and will apply to both U.S. and foreign flag existing gas vessels. When these new regulations are published, as a final rule, they will cover the remaining portions of the "Special Interim Regulations . . ." and that rule will be deleted. Regulations for froegin flag barges will then be incorporated into 46 CFR Part 151. Until that time, the owner of an *existing* foreign flag vessel should go to Part 154, and specifically to the "Special Interim Regulations . . .", Part 154a, to obtain the procedure and requirements for issuance of a Letter of Compliance.

It should be noted that the application dates listed in § 154.1 are prior to the effective date of these regulations. The application dates are the same dates contained in the IMCO Gas Code, which this rule is implementing. As stated in the preamble to the proposed rulemaking, published on October 4, 1976, 41 FR 43822, the Coast Guard began applying these standards to new ship construction on an ad hoc basis on March 11, 1975. Applicants requesting certification for the carriage of liquefied gases on ships were notified that compliance with the standards of the Gas Code were being applied to the maximum extent possible, taking into consideration the stage of each vessel's construction. This was done to ensure the safe carriage of liquefied gases at the earliest possible date.

Section 154.3. Commenting on proposed § 154.3(f), one commenter noted that cargo pump rooms and compressor rooms were not included in the definition of "cargo area", as is done in the IMCO Gas Code. They were not included in this definition since § 154.315 requires cargo pump rooms and compressor rooms to be in the cargo area and therefore it was considered redundant. Since it appears that confusion or misunderstanding may occur, the definition has been changed to include cargo pump rooms and cargo compressor rooms.

In proposed § 154.3(l) the "inner deck", used in some vessel designs, was not included in the definition of "Contiguous Hull Structure" and has been added.

The words " This does not include special fire control equipment which can be most practically located in the cargo area," that appear in the IMCO Gas Code definition of "control station spaces" were inadvertently omitted from proposed § 154.3(m). These words were included in the IMCO Gas Code to avoid confusion since dry chemical units are, in fact, required and permitted in the cargo area. To avoid any possible confusion, wording has been added to recognize that the presence of fire control equipment required or permitted to be in the cargo area does not make that space a "control space."

The definition of "essential auxiliary" was included in proposed § 154.3(p) since the term was in proposed § 154.178 with regard to hull structure heating systems. Due to a comment on proposed § 154.178, it was noted that the term was confusing since it may also apply to other systems and carries a definite connotation in some classification society rules. For these reasons it has been omitted from the definition section, and proposed § 154.178 no longer contains the term "essential auxiliary".

An important distinction between hold spaces of containment systems requiring secondary barriers and those not requiring secondary barriers was inadvertently omitted from proposed § 154.3(s)(4) and has been added.

Commenting on proposed § 154.3(jj), several commenters questioned the requirement for "nominal" metal to metal contact of valve operating parts, and whether it was intended to prohibit resilient-seated valves. It was the intent of the Coast Guard to exclude the use of resilient-seated valves as "shut-off valves." Shut-off valves are required when there must be complete flow stoppage, as for instance in a fire. Resilient-seated valves, although they may provide adequate service under normal operating conditions, are not expected to meet this criterion. Some specific types of resilient-seated valves have, however, been approved for use as "stop valves" on liquefied gas vessels but, where positive flow stoppage is required they may only be used in series with a "shut-off valve." For further discussion see the preamble remarks relative to proposed § 154.530.

Proposed § 154.3(uu), the definition of "recognized classification society", has been omitted. This term was used throughout the proposal to follow a similar statement in the IMCO Gas Code. After further review, the Coast Guard determined that the term was not sufficiently informative. 46 U.S.C. 391a provides for the adoption of rules of the American Bureau of Shipping (ABS), a recognized classification society, after public hearing. The publication of the notice of proposed rulemaking, October 4, 1976, and the public hearing on November 15, 1976, resulted in no public comment or question concerning the adoption of standards of a "recognized classification society". Accordingly, the Coast Guard adopts certain ABS rules pertaining to the efficiency of hulls as specific standards. Proposed § 154.3(uu) has been omitted and proposed §§ 154.170(a), 154.174(a), 154.176(a), 154.188, 154.195(b), 154.420(a), 154.421, 154.439, 154.440(c) and Table 1 have been changed accordingly.

It was suggested that in proposed § 154.3 definitions of the various independent tank types and process pressure vessels be added to the list of definitions since the terms are used throughout the regulations and not just in the sections dealing with their design. This has been done under the defintions for "Independent Tank" and "Process Pressure Vessel".

Finally, certain definitions were added, changed or deleted from this section as the result of comments on other proposed sections of the regulations. For a discussion of the reasons for these changes see the remaining preamble.

Section 154.5. Proposed § 154.5 was rewritten to clarify the required submissions for a Letter of Compliance application.

There were several questions on proposed § 154.5(a)(7) from foreign interests about the information required to be submitted with an IMCO Certificate of Fitness in order to waive plan review. Proposed § 154.5(a)(7) would require "Plans, calculations, or *other information* (emphasis added) to show compliance under * * *" to be submitted. The information the Coast Guard is seeking is evidence that the ship has been designed to meet the ambient conditions specified in § 154.466(a)(1) or (a)(2), the stress factors required for types B and C tanks in §§ 154.447 and 154.450, the requirement in § 154.170 for crack arresting steel in the hull, and the requirement in §§ 154.701–154.709 for cargo pressure/temperature control without venting. The model certificate contained in the Appendix to the IMCO Gas Code requires that the stress factors used in tank design and the ambient

design temperatures be specified. Appropriate entries in the IMCO Certificate would satisfy the requirement of § 154.5(a)(7) in these two areas. Finally, to show compliance with §§ 154.170 and 154.701 through 154.709, the Coast Guard would accept classification society certificates indicating that crack arresting steels have been used in the hull, and that a means of cargo tank pressure/temperature control, other than control via vapor venting, is available. Proposed § 154.5(a) was rewritten to clarify what required documentation was necessary to show compliance with these regulations.

Section 154.6. Commenting on proposed § 154.6(b), one commenter suggested that the Commandant could issue an IMCO Certificate of Fitness to a vessel that met the IMCO Gas Code but failed to meet U.S. regulations. Since the Coast Guard only issues IMCO Certificates to U.S. flag vessels, those vessels must meet U.S. regulations.

Section 154.8. Several comments were received concerning the applicability of these regulations to new or novel designs of cargo containment systems or new or different types of vessels. New technological advances, while not regulated by specific design criteria in Part 154, are covered by § 154.8(a), which requires that they be accepted by the Commandant and shown "to be as effective as that specified in this part." A similar statement of "equivalency" is contained in paragraph 1.5.1 of the IMCO Gas Code.

Section 154.10. Proposed 154.10(b) states that if a vessel carries cargoes regulated by Part 154 and another part, the requirements of both parts must be met. One commenter suggested that this statement could cause confusion if one part has higher minimum standards than the other. A vessel that meets one part's higher minimum standard would exceed (and, therefore, "meet") the other part's lower minimum standard. Accordingly, no change was made to this section.

Inspection and Tests

Subpart B—§ 154.40 through 154.142. Many comments were received on proposed Subpart B, entitled "Inspections and Tests". This subpart contains the Coast Guard's requirements for construction tests, original inspections and reinspections for Certificates of Inspections. Because several of the comments were very important and may require major modifications to the proposal, the Coast Guard determined that a complete review of this proposed subpart was necessary. In order to allow sufficient time to compare the requirements to those of classification societies, i.e. American Bureau of Shipping (ABS), and because the revised requirements would not have been finished in time to include them with this final rule, §§ 154.40 through 154.142 have been omitted. Once review and redrafting, if necessary, has been completed, the Coast Guard will determine whether or not the proposal has been changed to the extent that a new notice of proposed rulemaking is necessary. If not, these requirements will be published as a final rule in a future edition of the **Federal Register**. Until that time tests and inspections of liquefied gas vessels will be performed under the guidelines of 46 CFR Parts 30–40 (Subchapter D) of this chapter, and those additional requirements established by the Commandant (G–MMT) for the vessel.

Hull Structure

Section 154.170. One commenter suggested that in proposed paragraph (b) the longitudinal extent of required special hull steel grades should be specified. The Coast Guard agrees and has incorporated the suggestion by adding the words, "along the length of the cargo area—", to paragraph (b).

One commenter said that proposed paragraphs (b) and (c) did not give sufficient guidance to determine equivalent steel grades, and that additional guidance is needed regarding when Grade D vs. Grade E steel is required at the bilge strake. The commenter also said that a rolled gunwale plate of Grade E should be allowed as an option to using separate sheer and stringer plates of Grade E.

The Coast Guard does not agree with the initial comment. The details to show steel equivalence to Grades D and E are already outlined briefly in proposed paragraphs (b) and (c) as "* * * equivalent chemical properities, mechanical properties and heat treatment". The determination of steel equivalence to Grades D and E is through special approval by the Commandant (G–MMT). With reference to the final comments, for the bilge strake, either Grade D or E may be used at the builder's choice, and the rolled gunwale plate might be a suitable option and could be accepted under the equivalence § 154.8.

One commenter indicated that proposed paragraph (d), in referring to the effect of cargo on the outer hull steel temperature, was confusing. The Coast Guard agrees and believes confusion arose because the ambient design temperatures and the intent of paragraph 4.9.1 of the IMCO Gas Code were not included or properly conveyed in the proposed rule. The requirement has been clarified by omitting proposed paragraph (d), reorganizing and renumbering the section, adding a new paragraph (b)(3) which includes the design ambient temperatures of 0° C (32° F) still sea water and 5° C (41° F) still air and by adding the hull steel design condition that the secondary barrier, if one is required for the tank type, is assumed to be at the cargo temperature. The latter addition is based on both the Coast Guard's long standing position and the intent of paragraph 4.9.1 of the IMCO Gas Code that failure of the primary barrier, requiring use of the secondary barrier, is considered a design condition, and not only a casualty condition.

Additionally, the temperature below which the outer hull steel must meet the same material requirements as the continguous hull steel has been changed from that proposed in paragraph (d). The intent of this IMCO-based requirement was to provide Administrations with a means of comparing new ship/tank systems to existing acceptable designs in the area of hull temperature effects, and as such, the recommendation of a 0° C (32° F) temperature criterion was adopted by the Coast Guard in the proposed rule. The 0° C temperature criterion, however, proved unrealistic in practice, due largely to the "no velocity" water condition imposed for the theoretical calculation. Reassessment of the outer hull steel temperature criterion leads to the conclusion that a slightly lower temperature, namely −5° C (23° F), consistent with the degree of safety originally intended, should be adopted. Accordingly, this change has been made in new paragraph (b)(3) of this section.

Finally, several commenters questioned, in proposed § 154.170, the need for crack arresting steels in the hulls of gas ships when classification society rules do not require them. Classification society rules generally recognize the need for enhanced grades of steel in the hull as a means of crack arresting, based on material thickness, material toughness, and ship length. In gas ships, there are two considerations that are overlooked in classification society rules for crack arrestors. First, there is the possibility of a spill of liquefied gas causing a crack to be initiated. Crack arrestors are designed to prevent the crack from propagating into a catastrophic failure of the hull girder. Secondly, gas ships generally have double hulls. This permits the scantlings of the outer hull to be less than that required for a single skin vessel of comparable length while

providing the same level of hull strength. This normally results in the use of hull plating which is thinner than the minimum plate thickness for which classification societies require special heat treatment to improve notch toughness of the steel. A single skin vessel of comparable length would most likely have hull plating which is thicker than this minimum and therefore would require improved notch toughness. The Coast Guard, therefore, does not accept that the rules for single skin vessels carrying liquid cargoes are equally applicable to liquefied gas ships and the requirement for crack arresting steels in proposed § 154.170 has been retained.

Section 154.172. The Coast Guard noted that proposed § 154.172(a) should be changed as castings are not normally used in a hull structure. The words "and castings" have therefore been omitted.

Two commenters pointed out that reference to § 154.610 in proposed paragraphs (b) is incorrect. The reference has been changed to § 154.615 and the words "except the steel thickness limitation" have been omitted because they do not apply to § 154.615.

Finally, it was discovered that the term "design temperature" was incorrectly used in proposed §§ 154.172 (a) and (b) and in other sections of the proposal. As defined in proposed § 154.3(n), design temperature means "the minimum temperature at which cargo may be loaded, unloaded or carried". In some instances, especially §§ 154.170 through 154.182, the term was incorrectly used to mean the minimum temperature at which the contiguous hull materials exhibited adequate mechanical properties for the intended service. Since the contiguous hull does not contact the cargo under normal conditions this temperature is higher than the "design temperature". For this and other reasons, this incorrect usage and others appearing in the proposal have been corrected. The sections and paragraphs changed are: §§ 154.172 (a) and (b), Table 1, 154.174(b), 154.176(b), 154.176(b)(2), 154.180, 154.182, 154.465,154.512, 154.528 (b) and (c), and 154.702(a)(1).

Section 154.176. One commenter suggested that the reference to Alaskan waters in proposed § 154.176, should be changed to "waters in which Arctic conditions are encountered" as there is a possibility that U.S. flag vessels might trade in foreign ports with ambient conditions as cold or colder than Alaska. See the preamble discussion under § 154.466.

Sections 154.174 and 154.176. One commenter questioned the Coast Guard's requiring ambient air temperatures for Alaskan and other U.S. waters lower than those specified in paragraph 4.8.1 of the IMCO Gas Code. Also the use of −2°C (28°F) sea water instead of 0°C (32°F) was questioned. Paragraph 4.8.1 of the IMCO Gas Code allows each Administration to set minimum ambient temperatures lower or higher than the 0°C (32°F) sea water and 5°C (41°F) air, as specified by IMCO. The Coast Guard has required the proposed temperatures since 1966 for the lower 48 states and 1972 for Alaska. These lower ambients are based on surveys of actual minimum temperatures occurring in U.S. ports during the winter months. Accordingly, no change was made to this section.

The substance of proposed § 154.174(c) and 154.176(c) have been included in proposed § 154.178. The Coast Guard determined that for clarity the requirements for heat load calculations for contiguous hull heating systems should be included in § 154.178 with the remaining requirements for the heating systems.

Section 154.178. One commenter requested that a definition of "essential auxiliary" be included in proposed § 154.178(a). This is a term used in classification society rules to describe certain types of equipment for which inspections are required. Since it has a definite connotation in classification society rules, the term has been omitted from this section.

Section 154.182. Several commenters considered the requirement for production testing of contiguous hull structure, that does not act as a secondary barrier, to be performed for each 50 meters of weld to be too stringent. The Coast Guard concurs and has changed the proposed requirements to read "each 100m—(328-ft.) * * *"

One commenter suggested that when a weld fails both the initial Charpy V-notch test and the bend test, and also fails the subsequent retests, as required by proposed § 154.182(c), the weld seam should then be subjected to 100% radiographic or ultrasonic testing before a portion of the weld is repaired. He further suggests that this will determine the weld's soundness and freedom from flaws, and will aid in the determination of the extent of weld to be removed. The Coast Guard agrees that radiographic and ultrasonic testing will indicate flaws, however, the Charpy V-notch test and the bend test are used to determine the toughness, ductility and quality of the production weld. Radiographic and ultrasonic tests do not provide any information about toughness or ductility of the weld and, hence, these material properties must be evaluated through the use of the Charpy V-notch and the bend tests. The requested change was not made.

One commenter pointed out that 46 CFR 57.06-4, referenced in proposed paragraph (a), includes several types of bend tests and it was questioned which one was to be used. It was intended that all bend tests required by 46 CFR 57.06-4 be used as required for the plate thickness. Paragraph (a) has been changed for clarification.

Ship Survival Capability and Cargo Tank Locations

Section 154.200. One commenter questioned whether the vessel must be examined for the full range of drafts when the vessel only operates within a limited range of drafts. Proposed § 154.200 has been clarified by adding the word "operating" before the word "drafts" in the second line.

Section 154.205. One commenter stated that it was not clear in proposed § 154.205 whether or not water ballast was allowed to achieve positive metacentric height. Section 154.205 has been reworded to make it clear that water ballast is allowed.

Section 154.210. One commenter stated that the basic definitions of hull types found in paragraph 2.1.2 of the IMCO Gas Code should be contained in the regulations. This comment has been accepted and proposed § 154.210 has been changed.

Section 154.215. One commenter pointed out that in proposed § 154.215(e), 10 feet had been incorrectly rounded to 3.0 m instead of 3.05 m. This error has been corrected.

Section 154.225. Two commenters questioned the meaning of the free surface assumptions contained in proposed § 154.225(a). The designer is given two options. First, he may calculate the free surface effect of all liquids at an angle of heel of 5°. He would then use this value in all of his calculations. Second, he may calculate the free surface effect at every degree of heel by the moment of transference method. After reviewing the wording of proposed § 154.225(a), the Coast Guard finds that no change in the proposal is necessary.

Section 154.230. One commenter pointed out that the proposed wording of § 154.230 may permit a negative GM after damage. To prohibit this dangerous condition, a new paragraph (d) has been added to this section.

Four commenters pointed out that the proposed regulations do not contain any statement concerning the treatment of watertight superstructures. A new paragraph (e) has been included in

proposed § 154.230 to cover this consideration. The remaining paragraphs have been renumbered accordingly.

Section 154.235. One commenter asked if there is an exception for tank location in proposed § 154.235 for concrete hulls. These proposed regulations and the IMCO Gas Code address only steel hulled ships (see the preamble discussion for proposed § 154.1), and as such do not specifically outline standards for concrete hulls. The acceptance of such a design, including the subject of tank location, would be done under the provisions of § 154.8, *Equivalents.*

Ship Arrangements

Section 154.310. One commenter asked if gas freeing piping was included in the reference to purge piping in proposed § 154.310(a). "Purge" is commonly understood in the industry to mean the effective removal of undesirable vapors. With proper purging, the cargo piping or tank can be gas freed; therefore, the term "gas freeing," used in the IMCO Gas Code, is considered unnecessary by the Coast Guard and no change was made.

Commenting on proposed § 154.310(d), one commenter stated that drain lines for the interbarrier spaces may be located below deck. This is correct and is provided for in the IMCO Gas Code. The proposed section has, therefore, been changed to both provide for this piping location and to more clearly indicate the requirements for the cargo piping that must be located above the weather deck and that which must be in the cargo area. Proposed paragraph (d) is now paragraphs (d) and (e), and proposed paragraphs (e) and (f) are now designated (f) and (g) respectively.

One commenter questioned the meaning of "emergency dumping" as used in the preamble and § 154.310(d) of the proposal. The intent was to provide a means for emergency jettisoning of cago in the event of a primary barrier failure. The IMCO Gas Code requires that cargo leaked into an interbarrier space be returned to a cargo tank. This is clearly impractical if all tanks other than the leaking one are full. The Coast Guard determined that an alternative of jettisoning the cargo must therefore be included. The wording of proposed § 154.310(d) has been changed for clarification. Additionally, a new section was added at § 154.356 to describe the requirements for the emergency jettisoning arrangement required in §§ 154.350(c) and 154.1725(e).

One commenter suggested that in proposed § 154.310(e), the phrase "above the open deck" be changed to "above the weather deck". The Coast Guard agrees with this editorial change and the word "weather" replaces the word "open".

Section 154.315. One commenter suggested that the words "unless specially approved by the Commandant" be added to proposed § 154.315(a) to agree with the IMCO Gas Code. This suggestion was not accepted since the Coast Guard does not anticipate approving a design containing below deck cargo compressor or pump rooms.

Two commenters stated that proposed § 154.315(b)(2) should be changed to allow the use of pressure grease seals, equipment previously allowed by the Coast Guard. The Coast Guard agrees with this comment and the requirement now allows the use of pressure grease seals.

Section 154.320. One person suggested that the words "remote readout" be used instead of "indirect reading" in proposed § 154.320(b)(3). Remote readout instrumentation may not necessarily exclude cargo vapor from the cargo control room, therefore, the suggestion was not accepted and no change has been made to this paragraph.

Another commenter proposed to add the words "as far as practical" into paragraph (b)(3), as provided for in the IMCO Gas Code. The Coast Guard has determined that with the exception of gas detection equipment, any instrumentation of other than indirect reading type would allow unnecessary hazards in the gas safe cargo control room. The suggestion was not adopted and the requirement remains as proposed.

Section 154.325. One commenter stated that without modification of the definition of "Control spaces" in proposed § 154.3, proposed § 154.325(a) would prohibit locating dry chemical fire control equipment in the cargo area. The Coast Guard agrees with the commenter and did not intend to make this prohibition. Accordingly, the definition of "Control space" has been corrected to exclude any fire fighting units when these units are required or permitted. Paragraph (a) is correct as proposed.

Commenting on proposed § 154.325(b), one commenter submitted a drawing of an arrangement which included a triangular shaped cofferdam above the main deck used to separate the accommodation from the hold space. This may be acceptable, however, the intent of this section is twofold:

(1) To prevent gas from the hold space from entering safe spaces through a single weld failure; and

(2) To ensure that the cofferdam space is of sufficient size to allow internal inspection of the space.

Accordingly, the section has been changed to specify the minimum dimensions for clearance in this space.

Section 154.330. One commenter noted that "forced and natural ventilation exhausts" are included in proposed § 154.330(a) while not specifically included in the IMCO Gas Code. He suggests that this term be deleted. The Coast Guard does not agree and has determined that ventilation exhausts are included in paragraph 3.2.4 of the IMCO Gas Code as "openings to accommodations, service and control spaces", particularly in instances when the fan is not running. The comment, therefore, was not accepted.

Editorial changes have been made to proposed § 154.330(a) by correcting the minimum distance from 3 m (10 ft) to 3.05 m (10 ft), to agree with the IMCO Gas Code, and by adding the words "to accommodations, service, and control spaces," after the word "openings".

An editorial change has been made to proposed § 154.330(b) to agree with the distances in § 154.330(a)(1) and to use the same terminology for port lights used in the structural fire protection regulations, 46 CFR 32.56.

Commenting on proposed § 154.330(c), two commenters stated that waterlight doors with dogs on the wheelhouse would be heavy and unwieldly, may be improperly secured much of the time, and could not be operated as quickly as those without dogs. The Coast Guard agrees with this comment and omitted the requirement for dogs.

Commenting on proposed § 154.330(c), two commenters suggested that the purpose of this door was gas safety not water tightness. The Coast Guard agrees, however, the only method of ensuring gas tightness would be either an air test or a vapor leak detection test (for instance using helium) of the secured door. While these tests are acceptable, they would generally be impractical. The fire hose test, which can be done rather easily, is an adequate demonstration that the door's gasket is properly seated thus producing a good seal and making the secured door reasonably gas tight. Paragraph (c) has been rewritten to clarify the intent.

Editorial changes have also been made to proposed § 154.330(c) to specify the same distances as in § 154.330(a)(1) and to use the term "not fixed" in place of the term "open."

One commenter stated that the requirement in proposed § 154.330(e) for gasketed metal covers exceeds the IMCO Gas Code which uses the term "closing devices". The Coast Guard has determined that "closing devices" does not adequately describe the acceptable covers nor are gasketed metal covers the only type acceptable. This section has been changed to include metal covers which pass a tightness test.

Two commenters requested a definition of toxic cargoes. This had already been included in § 154.3.

Section 154.340. One commenter stated that the exemption for ballast spaces provided in paragraph 3.5.3(c) of the IMCO Gas Code was not included in proposed § 154.340(b). This comment is correct and the requirement now includes the IMCO Gas Code exemption for spaces separated by a single gastight boundary from hold spaces where a containment system requiring a secondary barrier is provided. Proposed § 154.340(b) and (c) have been rewritten and combined as § 154.340(b). The remainder of the section has been renumbered accordingly.

One commenter indicated that smaller size openings should be permitted if the integrity of the hold space insulation can be ascertained from outside the hold space while the tank is at the design temperature. Another commenter suggested that the minimum clear opening dimensions for void spaces, hold spaces and other gas-dangerous spaces be reduced to 15 inches by 23 inches (oval) and 18 inches in diameter (circular) when the larger dimensions could have an effect on major or principal ship dimensions. The Coast Guard does not agree with these comments. Except for those spaces which are exempted from the access requirements as noted above, accesses, where provided or required, must have the dimensions specified in proposed paragraph (b). The intent of this requirement is to allow entry and inspection of the spaces by personnel wearing protective clothing and breathing apparatus and, in the event of injury, to allow unconscious personnel to be removed from the space; therefore, no change has been made to the sizes specified.

Three commenters noted that proposed § 154.340(g) (renumbered (f)) apparently contains requirements in excess of the IMCO Gas Code by requiring the inspection of the hold space insulation from within the hold space while the tank is at the cargo temperature. That interpretation was not intended and this section has been changed accordingly.

Section § 154.345. One commenter stated that the distances specified in proposed § 154.345(b)(1) conflict with the IMCO Gas Code and should, therefore, be changed. Agreement has already been reached at a meeting of the IMCO Subcommittee on Bulk Chemicals, that the distances proposed in § 154.345(b)(1) will be included in the IMCO Gas Code as an amendment. Accordingly, the comment is not accepted.

One commenter felt that the requirement for mechanical ventilation in proposed § 154.345(b)(4) was redundant since the system in the gas-safe space would perform the same function. This double margin of safety was intended by the Coast Guard and IMCO (see paragraph 3.6.5 of the IMCO Gas Code) for gas safe spaces in the cargo area. Accordingly, the comment is not accepted.

One commenter considered the requirement in proposed § 154.345(b)(6) for twelve changes of air per hour to be unreasonable and that the requirement in proposed § 154.345(b)(5) for air locks to be maintained at a higher pressure than the gas dangerous zone to be sufficient. Although maintaining the space at an over pressure to the gas dangerous zone is one goal, the Coast Guard believes that continuous air changes are necessary to ensure safety. The proposed number of changes of air has been reduced to 8 per hour as is required for gas safe cargo control rooms.

Commenting on proposed § 154.345(c)(2), one commenter stated that the automatic deenergizing of electrical equipment upon loss of air lock pressure may be hazardous since atmospheric disturbances could give false signals. The source for this proposed requirement is the IMCO Gas Code, and the Coast Guard has determined that it would provide a necessary margin of safetly. Also, the air lock pressure should be high enough to preclude false signals due to atmospheric disturbances. Accordingly, the comment is not accepted.

Section 154.350. Two commenters noted that proposed § 154.350(d) prohibits conventional bilge suctions in such spaces as pipe tunnels, duct keels and void cofferdams. The proposed requirements of this section are identical to those contained in the IMCO Gas Code and the intent is to prohibit the possibility of cross connection between gas-dangerous and gas-safe spaces. A bilge system is an open system that could allow free communication of gases between a gas-dangerous space and a gas-safe one. Accordingly, the Coast Guard determined that the proposal should not be changed.

Section § 154.355. Commenting on proposed § 154.355, one commenter requested clarification concerning the use of bow and stern loading piping for toxic cargoes on type IIG/IIPG ships. § 154.1870(d) contains the necessary operational restrictions. Accordingly, this section was not changed.

Section § 154.356. See the preamble comments concerning proposed § 154.310(d).

Cargo Containment Systems

Section 154.406. Commenting on proposed § 154.406, one commenter pointed out that the loads need not always include "gas pressurization for cargo transfer." The Coast Guard concurs with the comment and for clarification has changed proposed paragraph (a)(11) in this section.

Section 154.407. Paragraph (a) in proposed § 154.407 has an error which has been corrected to read $a_\beta Z_\beta \gamma$; where:".

Paragraph (b) in proposed § 154.407 has been rewritten to clarify the definition of $(h_{sd})_{max}$ used in the equation for h_{eq} in § 154.407(a).

Section 154.409. One commenter said that the dynamic accelerations in proposed § 154.409, which are the same as those in section 4.12 and Figure 4.1 of the IMCO Gas Code, greatly exceed the dynamic accelerations the Coast Guard previously required in 46 CFR 38.05–2. The commenter also noted that the maximum allowable stress has not been changed and suggested that a change be made because allowable stresses and design criteria, such as dynamic loads, are related and not independent of each other. The Coast Guard does not agree with this comment. The criteria for dynamic loads in proposed § 154.409 is considered to be more representative of the actual loads experienced in service than those previously used. The regulations, as proposed, contain the allowable stresses which are based on the assumption that the designer will take all loads into consideration, including dynamic loads.

One commenter suggested that in proposed § 154.409(c), the definition of "L_o" be changed to reflect paragraph 4.12(d)(i) of the IMCO Gas Code which states that the length should be "as defined in Recognized Standards". The definition of "L_o" has been changed to read the same as the definition of length used by the American Bureau of Shipping.

Proposed § 154.409(c)(2) has been changed to state that the acceleration

formulae correspond to a 10^{-8} probability level for the North Atlantic Ocean for vessels over 50 meters in length. This statement was inadvertently omitted from the proposed regulations. This paragraph now agrees with section 4.12 of the IMCO Gas Code.

Section 154.427. One commenter suggested that proposed § 154.427 does not provide for equipment that protects a membrane system from pressure or vacuum which must, as a practical matter, always be included in the design of a membrane containment system. The Coast Guard agrees with the suggestion and has changed the wording of proposed § 154.425 to specify the components of a membrane tank system. Pressure control equipment was added as one of these components. Proposed § 154.427 was rewritten to clarify that the membrane tank system rather than the membrane or supporting insulation must be designed for the specified loads.

Section 154.439. Proposed § 154.439 has been changed to eliminate redundancy and to clarify that the intent of the section is to require that an independent tank type A meet the standards of the American Bureau of Shipping and also be designed for certain specified loads.

Section 154.444. Proposed § 154.444 has been changed to eliminate redundancy by omitting paragraphs (a) and (b) and adding reference to §§ 154.445 through 154.449.

Section 154.447. Several commenters pointed out that the maximum allowable stress required in proposed § 154.447(a) is less than that allowed by section 4.5 of the IMCO Gas Code. Specifically, proposed Table 2 required A=4.0 while IMCO requires only A=3.0 or A=3.5. The commenters suggested that the Coast Guard try to resolve the differences although they realized that it may require a change to the ASME Boiler and Pressure Vessel Code.

One commenter also said that the IMCO Gas Code does not invite individual administrations to set higher standards than in IMCO. The maximum allowable stress used by the Coast Guard is taken from Section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code. This Code is the basic standard used for the design of pressure vessels throughout North America and has been used in Coast Guard regulations for many years. At this time the Coast Guard does not consider it appropriate to deviate from that Code for liquefied gas tankers. Paragraph 4.5.1(d)(i) of the IMCO Gas Code states that the values of A, B, C and D should be at least the *minimum* specified in the table, which allows higher values to be used. At meetings during the development of the IMCO Gas Code, the Coast Guard repeatedly and consistently stated its intentions to set maximum allowable stress based on the ASME Code even if it was more stringent than the final version of the Code.

One commenter thought that some definitions and expressions for terms used in this section had been omitted. These terms have not been omitted and are contained in Appendices A and B to Part 154 which are referenced in this section.

Section 154.448. Two commenters suggested that the value of C_w in proposed § 154.448 could be greater than 0.5 if supported by analysis and testing as allowed by paragraph 4.4.5(f) of the IMCO Gas Code. The Coast Guard recognizes a C_w equal to or less than 0.5 as being the "state of the art" for fatigue analysis, however, in order to follow the IMCO Gas Code more closely and to allow for a more sophisticated analysis, paragraph (g) of § 154.448 has been rewritten to allow values of C_w more than 0.5 if specially approved by the Commandant (G–MMT).

Section 154.451. Two commenters indicated that the definition of "σ_m" in proposed § 154.451 was incorrect because the word "membrane" was omitted. The definition has been corrected to read "Design primary membrane stress".

One commenter suggested that "at the design temperature" should be included in the definition of "ρ". The Coast Guard agrees with the commenter, however, no change has been made since "specific gravity (ρ)" is defined in § 154.3 and includes consideration of the cargo temperature.

Section 154.459. Two commenters suggested an addition to proposed § 154.459 to allow for future designs that could have a different secondary barrier arrangement. New or novel designs not included in this section are provided for in § 154.8. For further discussion see the preamble discussion for § 154.8.

Several commenters pointed out that the reference in proposed § 154.459(d)(1) is incorrect because § 154.600 does not exist. The correct reference to §§ 154.605 through 154.630 has been substituted.

Section 154.460. Proposed § 154.460(a) has been changed to distinguish between the design capacity requirement for partial and complete secondary barriers.

Section 154.466. Two commenters objected to the more severe design ambient temperatures proposed under § 154.446 and under proposed §§ 154.174 and 154.176. One commenter said that unless U.S. ships could be built to the IMCO Gas Code design ambient temperatures, they could not compete economically with foreign flag vessels on routes other than those to U.S. ports. The other commenter thought the Coast Guard should make further investigations to determine the exact behavior of different steels of varying toughness at different ambient temperatures and under various load conditions. Both commenters suggested that proposed § 154.466 be rewritten to indicate that the specified design ambient temperatures are for unrestricted service and that warmer temperatures, including but not exceeding those allowed by the IMCO Gas Code, be allowed depending on the circumstances.

IMCO assumes a minimum ambient air temperature of 5° C (41° F) for worldwide service. This clearly does not realistically reflect prevailing temperatures in many U.S. ports year round. Existing Coast Guard regulations (46 CFR 38.05–2(c)) specify −18° C (0° F) *still air,* while the proposed regulations specify −18° C (0° F) air at *5 knots* for service to all U.S. ports except those in Alaska. For Alaskan service, air temperature for design purposes would be −29° C (−20° F) at 5 knots, and sea water at −2° C (28° F). These temperatures reflect actual minimum temperatures occurring in U.S. ports during the winter months. The design temperatures proposed have been in use for several years by designers of foreign vessels that are designed to engage in U.S. trade, and by the designers of gas ships that are designed for U.S. flag. Accordingly, the Coast Guard sees no reason to change the proposal. Further, the Coast Guard does not intend to perform new research on the effects of temperature on hull steel as the effects are well known. The Coast Guard would welcome any submitted data regarding the combined effects of temperature and loading on hull steels.

Concerning the final comment, the Coast Guard has required the proposed Alaskan ambients since 1972 and has never allowed restricted Alaskan service based upon the seasonably warmer temperatures prevailing during certain portions of the year. The Coast Guard is continuing with this policy in the future. Service to Alaska will only be allowed if the contiguous hull structure is adequately designed based upon the minimum cargo carriage temperature and the Alaskan design ambients. Depending upon the design of the vessel, carriage of certain cargoes to and from Alaska may be authorized

while other cargoes, carried at lower temperatures, are prohibited. These carriage limitations will be noted on the Certificate of Inspection or on the *Cargoes and Restrictions* list which is included with the Letter of Compliance.

One commenter suggested that some foreign ports, where U.S. gas ships may be trading, may also require the use of lower ambient design temperatures. There is the possibility of U.S. ships trading in cold weather ports in other parts of the world where ambient conditions are comparable to those in Alaska, however, the Coast Guard has not received proposals for U.S. gas ships trading to such ports as yet, and consequently temperature statistics have not been collected for foreign ports. The comment is well taken but cannot be addressed at this time.

Section 154.470. One commenter noted that proposed § 154.470(c) is more restrictive than paragraph 4.6.7 of the IMCO Gas Code, which allows plastic deformation that does not endanger the hull structure when anti-flotation loads are considered. The Coast Guard agrees with this comment and has changed paragraph (c) to allow plastic deformation that would not endanger the hull structure.

Cargo and Process Piping Systems

Section 154.506. Two commenters objected to an implied limit on the number of mechanical expansion joints used in a piping system. It was suggested that if specific restrictions are intended, they should be included in the regulations in order to provide guidance to designers.

This section is intended to follow paragraph 5.2.1(b) of the IMCO Gas Code which specifies that the use of the mechanical expansion joints should be kept to a minimum. This is also the long standing policy of the Coast Guard when specially approving the use of mechanical expansion joints in piping systems on liquefied gas carriers. To clarify the requirements, the proposed section was rewritten by combining the requirements of proposed §§ 154.506 and 154.508 into one section. The requirement in proposed § 154.506 for "the number of mechanical expansion joints to be specially approved by the Commandant (G–MMT)" was replaced by a new paragraph (a) which specifies the conditions for use of mechanical expansion joints outside of the cargo tanks. New paragraphs (b) and (c) have also been added to § 154.506 to replace proposed § 154.508. The preamble discussion of proposed § 154.508 explains paragraph (c) which is different from the requirements in proposed § 154.508(b).

Section 154.508. Many commenters objected to proposed § 154.508, which required a cover on bellows expansion joints to prevent icing damage. The commenters' reasons for not installing a cover included:

(1) The need for visual inspection for corrosion, leakage, or damage before and during use.

(2) Water could be trapped under a cover and could cause pitting and stress corrosion.

(3) Trapped water would freeze and could cause a greater ice buildup than if the bellows were not covered.

(4) The experience and standard of industry are not to cover bellows expansion joints.

The Coast Guard concurs and has changed the requirement by omitting § 154.508 and by adding new paragraphs (b) and (c) to § 154.506.

Section 154.514. Two commenters recommended that the method of electrical bonding be specified in proposed § 154.514. It was suggested that separate pipe sections which are each grounded to the hull need not have an additional electrical bond across their connections. It was also suggested that bolted flange connections which provide metal to metal contact between the bolts and both flanges need not have a separate bonding strap across the connection. These are universally accepted methods of electrical bonding and the Coast Guard agrees with both suggestions. In order to clarify the intent of the term "electrical bond", and to indicate the acceptability of these techniques, the Coast Guard has added these methods to this section as a new paragraph (c). Additionally, metal to metal contact between adjacent parts under normal operating conditions has also been added as an acceptable method of electrical bonding.

Another commenter questioned if the intent of the Coast Guard, when including hose connections in proposed § 154.514(b), was to require ship to shore grounding, noting the permissive, but not mandatory, provision for a ground connection in 46 CFR 35.35–5. The Coast Guard's intent was not to require ship to shore grounding but to require that the metallic end fitting on a hose connected to ship's piping be grounded. Proposed paragraph (b) has been changed for clarification.

Section 154.519. Two commenters suggested that in proposed § 154.519, the liquid relief valves in the cargo piping system be allowed to discharge into either a cargo tank or a cargo vent mast. § 154.519 (a) and (b), have been changed to allow either method of discharge.

One of the commenters suggested that a prohibition of shut-off valves in the relief valve discharge lines to the cargo tanks should be included. The other commenter said that proposed § 154.519 is in conflict with proposed §§ 154.530(a) and 154.532(a) which require shut-off valves at all tank connections. The Coast Guard does not agree with either comment. Shut-off valves are required at all tank connections to allow complete isolation of a tank and prevent any flow into or out of the tank. For a relief valve to discharge directly to a cargo tank, it would be necessary to arrange the piping to allow an alternate path for the relieved liquid should the valve at the cargo tank be closed. As discussed in the previous paragraph, there is also the alternative of discharging to a vent mast. While the two sections may appear to be in conflict at first glance, there are several arrangements that can meet both requirements.

One commenter also suggested that a relief valve discharging to a cargo vent mast be installed above the cargo piping it protects to improve the likelihood of vapor being discharged. This arrangement might be advantageous and is not prohibited by the proposed section, however, the Coast Guard does not consider it necessary to make it a requirement.

Section 154.520. One commenter suggested that vibration and wind loads be included as design considerations in proposed § 154.520. No change has been made to this section so that it remains equivalent to paragraph 5.2.7 of the IMCO Gas Code which lists the same loads included in § 154.520 (a) through (e). The Coast Guard considers vibration and wind loads less important than the listed loads but this does not prevent the designer from including them in his analysis when he thinks they are necessary.

Proposed § 154.520 has been changed to require that stress analysis for piping with a design temperature of −110° C (−166° F) or lower be "specially approved by the Commandant (G–MMT)." This wording was inadvertently omitted from the proposal and was added to follow paragraph 5.2.7 of the IMCO Gas Code which states that the stress analysis, "should be submitted to the administration."

Section 154.522. One commenter suggested that in proposed § 154.522 steel pipe meeting ASTM A333, grade 1, should be allowed for open ended piping inside cargo tanks at temperatures of −55° C (−67° F) or warmer. In 46 CFR 56.50–105, the Coast Guard allows pipe

meeting the suggested standards to be used at temperatures of −34.4° C (−30° F) or warmer. The Coast Guard, therefore, does not agree with the suggestion for open ended piping inside cargo tanks; however, this material could be considered for open ended vent piping as allowed in this section.

Section 154.524. Two commenters noted that socket weld fittings were not included as an acceptable means for joining pipes in proposed § 154.524. The commenters suggested that the fittings be allowed for pipe sizes of either three inches or two inches and less, without temperature limitations. The Coast Guard agrees with these comments and since socket weld fittings, such as socket weld flanges under § 154.528, are acceptable to the Coast Guard, they have been included in a new paragraph (c), however, the size has been limited to pipe sizes of 50 mm (2 in.) or less, and design temperatures of −55° C (−67° F) or warmer which is the same requirement for socket weld flanges. The paragraph proposed as (c) has been designated (d) and a new paragraph (e) has been added to allow other fittings or methods of joining pipes that are specially approved by the Commandant (G–MMT).

Section 154.528. One commenter noted the exclusion of nominal pipe size 100 mm (4 in.) and 50 mm (2 in.) in proposed §§ 154.528 (b)(1) and (b)(2) respectively. Paragraphs (b)(1) and (b)(2) have been corrected to read "100 mm (4 in.) or less," and "50 mm (2 in.) or less" respectively.

Section 154.530. One commenter stated that proposed § 154.530 conflicts with proposed § 154.1310 because the former section excludes a closed gauging device from the requirement for a tank shut-off valve while the latter section requires it for closed gauges not mounted directly on the tank. A similar conflict occurs in § 154.536 which requires a quick-closing shut-off valve or excess flow valve on tank gauge connections if the gauge allows an outward flow greater than the flow through a 1.4 mm hole. Proposed § 154.530(a) has been changed to clarify the requirement by adding the word "tank" before the words "safety relief valve", by adding the words "other than those under §§ 154.536 or 154.1310" after the words "gauging devices", and by rearranging the text. These changes eliminate any apparent conflict with the requirements in §§ 154.536 or 154.1310.

For clarification, proposed § 154.530(a)(3) has been changed to read "are capable of local manual operation" and is now redesignated § 154.530(a)(2). The words "manual control" were changed to "local manual operation" to clarify the intent that the valve must be able to be opened and closed manually. A new paragraph (a)(3) has been added to permit the valve to be remotely controlled. This wording reflects that used in paragraph 5.3.1(a) of the IMCO Gas Code.

One commenter suggested that in proposed § 154.530(a) the required shut-off valves on tank vapor connections be allowed to have resilient seats instead of the "nominal metal to metal contact" included in the definition of shut-off valve in § 154.3. The commenter said the lower leakage rate of a resilient seat would be preferable to the greater degree of fire protection provided by a metal to metal seat.

The Coast Guard does not concur as the degree of fire protection is the more important consideration. These regulations do not prohibit a second valve with a resilient seat from being used in series with the required shut-off valve if less leakage is desired during normal operating conditions. To clarify the type of valve which is required, reference to the definition of a "shut-off valve" was added to proposed § 154.530(a). Additionally, proposed § 154.530(a)(1) was omitted since it is already included in the definition of "shut-off valve".

Section 154.532. The comments received for proposed § 154.530 also apply to proposed § 154.532. The same changes have been made to proposed paragraph (a) as were made to § 154.530(a).

Commenting on proposed § 154.532(a), one commenter objected to requiring a manually controlled stop valve and a quick-closing shut-off valve since the quick-closing shut-off valve is already required under § 154.540 to have manual control and, therefore, could perform the function for both valves. Proposed § 154.532 follows paragraph 5.3.1(b) of the IMCO Gas Code which requires both valves unless the quick-closing shut-off valve is capable of performing all the functions of a manually controlled stop valve. Specifically, the valve must be capable of being opened and closed manually and, once manually closed, the valve must only open manually. To clarify this requirement, paragraph (c)(2) of proposed § 154.532 has been changed to read "is capable of local manual operation". Also, see the discussion on proposed §§ 154.540 and 154.544 for similar changes to those sections.

Section 154.534. For clarification the word "cargo" has been inserted before the word "compressors" in proposed § 154.534.

Section 154.538. Proposed § 154.538(a) has been changed by adding references to §§ 154.540 and 154.544. This was done to clarify which requirements the remotely controlled quick-closing shut-off valve must meet.

Section 154.540. One commenter suggested that in proposed § 154.540 the location for the controls to operate the emergency shut down system should be designated as the "normal operating position of the person in charge of cargo transfer operations." Paragraph 5.3.4 of the IMCO Gas Code requires that the location of the controls include the cargo control room or cargo loading station. The Coast Guard has followed the IMCO Gas Code by requiring controls in at least two locations remote from the valves with controls in each cargo control station. If there are two or more cargo control stations, single controls in each of these locations will satisfy the requirements. This commenter's suggestion would have been allowed under proposed § 154.540(b)(2), and the suggested change was not necessary.

In response to comments on proposed § 154.532, which have been previously discussed, several changes have been made to clarify the requirements of § 154.540. The word "control" has been changed to "shutdown" wherever it applies to the "control system", to better describe the purpose and function of the system. Also, the word "operate" which implies both opening and closing has been changed to "close". As a practical matter, it is realized that the system will probably be able to both open and close the valves, however, the emergency shut-down system is only required to close the valves.

To incorporate these changes, proposed § 154.540(b)(1) has been changed by adding a reference to § 154.320 and proposed paragraph (c) has been omitted and the requirements moved to § 154.544. Finally, since the fusible elements are an integral control element of the emergency shut-down system, the substance of proposed § 154.542 has been added to proposed § 154.540 and proposed § 154.542 is omitted. All references to § 154.542 have been omitted. The proposed section was rewritten to clarify the requirements, eliminate redundancy and to separate the design requirements for the emergency shut-down system from the design requirements for the quick-closing valves.

Section 154.542. See the preamble comments concerning proposed § 154.540.

Section 154.544. Two commenters questioned the 30 second maximum closing time in proposed § 154.544 as

being arbitrary and possibly causing a pressure surge that could damage long loading lines at some shore terminals. The Coast Guard is aware of the pressure surge problem and is investigating possible solutions which might require a future change to these requirements. For the present, the 30 second maximum closing time is considered reasonable and it is necessary to define "quick-closing". It should be noted that other measures, such as reduced loading rates, can be used to reduce the pressure surge.

To clarify this section several changes were made as follows:

(1) A reference to the definition of a shut-off valve was added as paragraph (a).

(2) The required closing time in proposed § 154.544 was changed to read ". . . 30 seconds or less," and is now in paragraph (b).

(3) The requirements omitted from proposed § 154.540(c) were added to § 154.544 as new paragraphs (c) and (d).

(4) Paragraph (d) was reworded the same as article 5.3.4 of the IMCO Gas Code and clarified that the quick-closing valves need be "capable of local manual closing" rather than "have manual control".

Sections 154.552–154.562. Commenting on proposed §§ 154.552 to 154.562, one commenter suggested it be specified that the requirements for cargo hose are applicable only to cargo hose carried on board the vessel. He further suggested that requirements for hoses furnished by the shore facility should be covered by shore facility regulations. The Coast Guard concurs and to state this limitation, a new § 154.551 has been added to the proposed rule.

Section 154.554. For clarification an editorial correction has been made to proposed § 154.554 by changing the words "pressurized by the tank" to "exposed to the pressure in the cargo tank."

Section 154.558. One commenter suggested that each cargo hose under proposed § 154.558 be marked to indicate the products for which it has been approved. This suggestion was not adopted because the Coast Guard does not consider it practical to mark a hose with all cargoes for which it could be used. The requirement to mark maximum working pressure and minimum service temperature is considered sufficient. It should be noted that the proposed section does not prohibit a vessel operator from marking the hoses for the cargoes carried by his vessel. This could be advantageous to operating personnel. Also it should be noted that proposed § 154.1725(b) requires marking of cargo hoses used for ethylene oxide.

Section 154.560. In response to comments on proposed § 154.1858, proposed § 154.560 has been rewritten to note that the hose used for the prototype test cannot be used as a cargo hose.

Materials

Sections 154.605 through 154.620. One commenter said that in proposed §§ 154.605 through 154.620 it was difficult to determine the Coast Guard requirements which were in addition to the provisions of the IMCO Gas Code. He suggested that the regulations be separated into requirements based on the IMCO Gas Code and additional Coast Guard requirements, if any. The commenter also suggested that certain other provisions of Chapter 6 of the IMCO Gas Code be included in these regulations. The Coast Guard does not accept these suggestions. Those IMCO requirements of Chapter 6 not specified in proposed §§ 154.605 through 154.620 are already contained in other U.S. Coast Guard regulations, which are referenced in the appropriate sections. (§ 54.25–10, which is referenced in proposed § 154.615, has been changed in this document to agree with Table 6.2 of the IMCO Gas Code.) Additionally, for certain details of Chapter 6, the IMCO Code allows the approving administration to establish the standards within certain guidelines. For clarity and to avoid future confusion, the Coast Guard has chosen to specify the acceptable standards in these regulations. Finally, since the four areas in which Part 154 exceeds the IMCO Gas Code have been outlined in the preamble to this rule and the Notice of Proposed Rulemaking, no separation of the regulations is needed.

Commenting on proposed §§ 154.610, 154.615 and 154.620, one commenter suggested the following:

(1) Deletion of the word "castings" from these sections since castings are not included in Tables 6.1, 6.2 and 6.3 of the IMCO Gas Code;

(2) Requiring "fine grain practice" only in plates in proposed § 154.610(a) since forgings and shapes may not be made using "fine grain practice"; and

(3) That low alloy steels should be acceptable under proposed § 154.610(a), in addition to carbon-manganese steel for service temperatures not colder than 0° C (32° F).

The Coast Guard concurs with the suggestions and has made changes as follows:

(1) The word "castings" has been deleted wherever it appeared in proposed §§ 154.610, 154.615 and 154.620.

(2) Proposed § 154.610(a) has been divided into three new paragraphs (a), (b) and (c) and changed to require "fine grain practice" only for plates.

(3) Materials other than carbon manganese steel have been included under § 154.610(b) by adding references to §§ 154.615, 154.620, and 154.625.

Section 154.610. One commenter objected to the material requirements in proposed § 154.610 being applied to process pressure vessels. He states that many materials currently being used have proven satisfactory in service and their use in process pressure vessels would be prohibited under the proposed requirement. Additionally, the commenter claimed that adherence by the manufacturer to the proposed material requirements would make each component "special", thus increasing cost and lead times. It was suggested that the Coast Guard continue applying the material requirements of 46 CFR Part 54, which the commenter considers to be adequate.

The Coast Guard agrees that the current requirements for materials used in pressure vessels under 46 CFR Part 54 are sufficient and has changed proposed § 154.610 by making the section applicable only to "cargo tanks". Also, an addition has been made to proposed § 154.610 to emphasize that cargo tank materials for service at or above 0° C (32° F) must meet the ASME Code requirements under 46 CFR 54.25–1 and 54.25–3.

Pipes and tubes have been eliminated as product forms subject to the requirements of § 154.610. This follows Table 6.1 of the IMCO Gas Code which specifies "normal practice" for seamless and welded pipes and tubes. The Coast Guard considers this adequately addressed in 46 CFR Part 56.

Section 154.615. One commenter noted that proposed § 154.615 sets the upper temperature limit for low temperature operation at 0° C (32° F), as specified in the IMCO Gas Code. This differs from the previously required Coast Guard temperature limit of minus 18° C (0° F). The commenter claims this will affect a large group of process pressure vessels, used in LPG/NH_3 reliquefaction systems, which operate between 0° F and 32° F since they will now have to meet the requirements for low temperature service. It was suggested that the 0° F cut-off temperature be retained.

The Coast Guard agrees and has changed proposed § 154.615 by making this section applicable only to cargo tanks and secondary barriers. Process

pressure vessels must meet 46 CFR Part 54 as required by § 154.450.

Section 154.620. In response to comments on proposed § 154.630, a new paragraph (b) was added to this section to include aluminum alloys. Because of the addition of aluminum alloys, extruded bars and shapes have been added as product forms in this section.

Section 154.630. One commenter pointed out that aluminum alloys are not mentioned in proposed § 154.610, § 154.615, or § 154.620, when in fact, many LNG cargo tanks in the United States are being constructed of aluminum. It was suggested that aluminum be included other than in proposed § 154.630(b). The Coast Guard agrees and has included aluminum alloys in § 154.620(b).

The same commenter also questioned the intent of proposed § 154.630(b). He understood it to mean that aluminum alloys, which are used for independent tank types A and B, must be in the annealed condition. The commenter objected suggesting that this would essentially prevent the use of heat treated alloys such as 6061–T4, which have been used for piping inside tanks. It was suggested that heat treated alloys not be eliminated. The Coast Guard's intent was to follow paragraph 4.5.1(f)(i) of the IMCO Gas Code which states that for welded connections the minimum tensile strength used in determining allowable stress should correspond to the tensile strength of the alloy in the "as fabricated condition" (annealed condition). Proposed paragraph (b) has been rewritten to clarify this.

Construction

Section 154.650. One commenter suggested that proposd § 154.650(b), which references 46 CFR 57.02–4, should also include an allowance for the use for weld filler metals approved by classification societies other than the American Bureau of Shipping (ABS). This is needed especially for ships that will be foreign built to meet U.S. regulations. A provision allowing the use of filler metals other than those approved by ABS is already included in 46 CFR 57.02–4(b). Accordingly, no change was made to this section.

Section 154.655. One commenter noted that proposed § 154.655(b) appears to require mandatory stress relieving of independent type C tanks constructed of materials other than carbon or carbon manganese steels, with the details of the procedure being specially approved by the Commandant (G-MMT). The commenter suggests that tanks constructed of materials such as 9% nickel steel, stainless steel and aluminum do not need stress relieving. The Coast Guard agrees with the commenter that not all materials requires stress relief. The requirement has been clarified by changing proposed paragraph (b) to indicate that tanks, constructed of materials other than carbon and carbon manganese steel, be stress relieved in accordance with 46 CFR Part 54.

One commenter objected to the limitations on mechanical stress relief in 46 CFR Subpart 54.30, referenced in proposed § 154.655, which allows mechanical stress relief in lieu of thermal stress relief provided the tank shell thickness is 1 inch or less. The commenter suggested that this limit be increased to 30 mm (1.18 in.) which has been allowed by some classification societies. The Coast Guard is currently reviewing this problem and is considering a change to 46 CFR Subpart 54.30 to increase the tank shell thickness limit. If a change is made, it will be published in a future notice of proposed rulemaking. Accordingly, no change is now made to 46 CFR Subpart 54.30.

Section 154.660. Two commenters questioned proposed § 154.660 asking whether it was intended that longitudinal butt welds be included in proposed paragraphs (b) and (c) in addition to girth butt welds. For purposes of this section, a longitudinal butt weld is considered to be included under the term "butt weld" when it is in a piping component other than a component manufactured to a standard specification under 46 CFR 56.60–1. For clarification proposed paragraph (b) has been changed to specify which type of butt welds must meet the requirements of this section.

One commenter stated that proposed paragraph (b) requires both mandatory post-weld heat treatment and compliance with 46 CFR 56.50–105 and Subpart 56.85. He further states that these requirements conflict with paragraph 5.2.10(f) of the IMCO Gas Code since IMCO permits exclusions from post-weld heat treatment for materials less than 10 mm thick. The Coast Guard does not agree that a conflict exists. IMCO allows exclusions from post-weld heat treatment at the "Administration's" discretion. The Coast Guard, representing the "Administration", has decided to continue with present U.S. regulations as contained in Subchapter F, specifically § 56.50–105(a)(3), which does not permit general exclusions based upon material thickness. However, to clarify this requirement, proposed paragraph (b) has been changed to require post-weld heat treatment only when required by 46 CFR 56.50–105. Due to other changes to this section this paragraph is now designated paragraph (b)(1).

Also commenting on proposed paragraph (b), one commenter recommended that the requirement for post-weld heat treatment be reevaluated, since in the past several vessels have been exempted from this requirement and have performed satisfactorily. It was further suggested that if the requirement is deemed necessary, then it should be limited to a specified range of service temperatures. The Coast Guard does not consider a few isolated incidents of satisfactory performance as adequate justification for changing a long standing, well-founded requirement. Additionally, the service conditions of pressure and temperature for which post-weld heat treatment is required are specified in the referenced regulation. Accordingly, this recommendation was not accepted.

Two commenters had questions or suggestions regarding the requirements for radiographic testing of welds. One commenter suggested that for open ended vent pipes the requirement for radiographic testing of butt welds should be reduced from 100% to 10% random radiography. The Coast Guard does not agree. This requirement is consistent with the current requirements of 46 CFR Subpart 56.95 requiring 100% radiographic testing for Class II–L piping. The Coast Guard has, however, determined that cargo piping inside independent cargo tanks need not be 100% radiographically tested and has changed proposed paragraph (c)(1) accordingly. Radiographic testing of piping inside membrane or semi-membrane tanks is still required since these tanks could be damaged should the cargo piping fail.

The other commenter noted that the proposed rule requires radiographic testing of butt welds in pipes with an inside diameter greater than 100 mm while paragraph 5.2.10(f) of the IMCO Gas Code requires radiography for all pipes with an inside diameter greater than 75 mm. The commenter asked whether this apparent liberalization was intended.

The Coast Guard intended to incorporate the requiremens of 46 CFR 56.95–10 into proposed § 154.660. Unfortunately, the diameter restriction was mistakenly included in the proposal as *"inside* diameter of 100 mm", rather than *"nominal* diameter of 100 mm" (this is considered to be equivalent to nominal 4 inch pipe). Using the word "nominal", proposed paragraph (c)(1) is consistent with § 56.95–10 of this

chapter and is equivalent to paragraph 5.2.10(f) of the IMCO Gas Code. Hence, no liberalization was intended or given. The word "inside" has been changed to "nominal" in proposed paragraph (c)(1) (renumbered paragraph (b)(2)).

Cargo Pressure and Temperature Control

Section 154.701. Several commenters expressed concern that proposed § 154.701(a)(1) could be interpreted as requiring separate refrigeration systems for each tank. As this was not intended, the wording has been changed to reflect the acceptability of an arrangement where each tank is served by a common system.

Several commenters felt that in proposed § 154.701(a)(2) MARVS should have been used as a design criteria in lieu of P_o. Paragraph 7.1.1 of the IMCO Gas Code, on which this section is based, refers neither to P_o nor MARVS, but system design pressure at upper ambient conditions. This section has been changed to reflect the proper pressure standard, and now requires that the safety relief valve be set at a pressure which is equal to or greater than the vapor pressure of the cargo at 45° C but not greater than the MARVS.

One commenter noted that design of containment systems to the standard in this section was limited to independent tanks type C, a restriction not included in the IMCO Gas Code. Since other types of tanks could meet the standard for relatively low vapor pressure gases, that restriction has been removed.

One commenter requested that proposed § 154.701(b) be changed to include the alternatives to separate refrigeration systems for incompatible cargoes as stated in paragraph 7.2.2 of the IMCO Gas Code. Should a suitable alternative to separate systems be developed, the Coast Guard could accept it on the basis of equivalence. Accordingly, this change was not incorporated into this section. Proposed paragraphs (a) and (b), however, were combined for clarification of the requirements.

One commenter suggested that vessels carrying certain cargoes (e.g. LNG) be permitted to control cargo tank pressure by venting, as in paragraph 7.1.1(e) of the IMCO Gas Code. The Coast Guard does not allow the atmospheric venting of hazardous cargoes under normal operating conditions. There are adequate alternatives for controlling the cargo vapors that are generated during normal operations and carriage. Many of these techniques are in this proposed section. The Coast Guard recognizes that in emergencies atmospheric cargo venting may be the only feasible method to prevent a tank rupture; however, since alternatives are available during normal operations, amtospheric venting has not been added to this section.

The same commenter requested that provision for other systems for pressure and temperature controls be made, as in paragraph 7.1.1(d) of the IMCO Gas Code. The proposed methods of control provide an adequate range of alternatives. Additionally, since there is a mechanism for evaluating other alternatives as equivalents, paragraph 7.1.1(d) will not be specifically included in these regulations.

Section 154.702. One commenter noted that the pressure criteria in proposed §§ 154.702(a)(1) and 154.703 should have been the MARVS in lieu of P_o. The Coast Guard does not agree with this commenter. The correct pressure criteria is the set pressure of the cargo tank safety relief valve. This correction was made to the proposal.

One commenter requested that proposed §§ 154.702(a)(1) and 154.703 clearly allow a refrigeration system to serve a number of tanks. The former section has been changed to clarify this point for both sections.

Wording was added to proposed § 154.702(c)(1) to clarify that the excess capacity of a refrigeration heat exchanger is calculated as a percentage of the *required* capacity, not the actual capacity.

Two commenters noted that the distinction between "essential service" and "interference with essential service" was not recognized in proposed § 154.702(dj(3), as it was in paragraph 7.2.3 of the IMCO Gas Code. This section has been changed to include this consideration.

One commenter suggested that the types of refrigeration systems, described in paragraph 7.2.4 of the IMCO Gas Code, should also be described in proposed § 154.702(e). This suggestion was not accepted since the descriptions appear in proposed Subpart D—Special Requirements, where their inclusion is more appropriate.

One Commenter indicated that the requirement for automatic and manual cargo temperature controls in proposed § 154.702(f) were in excess of IMCO requirements. It was not the intent of the Coast Guard to require automatic cargo temperature control for each refrigeration system, but rather to ensure that manual control was always provided. Since manual control, via at least an on-off power switch, is always available, it was decided that this requirement was unnecessary. Accordingly, this paragraph has been omitted, and proposed paragraph (g) has been designated paragraph (f).

Section 154.703. Two commenters questioned the 21 day retention requirement in proposed § 154.703. One suggested that it was in excess of the previously mentioned 14 day criterion, while the other questioned if it was applicable to all vessels regardless of the length of the transport voyage. The 21 day criterion is applicable regardless of normal voyage length. The 14 day criterion does not exist. The confusion stems from a requirement related to secondary barrier performance for 15 days in the case of primary barrier failure. Accordingly, no change was made to this section.

Section 154.705. One commenter asked whether proposed § 154.705(c) precluded the burning of 100% boil off gas at sea. Reference in § 154.705(c) to § 154.1854 was inserted to indicate the acceptability of this mode of operation.

Section 154.706. One commenter suggested that the rate of air change required in proposed § 154.706(a)(2) for gas fuel line vent ducts specifically include consideration of the ruptured fuel line condition. Because the minimum rate specified in this proposal is consistent with the IMCO Gas Code, the Coast Guard did not change the requirement. Factors such as a ruptured fuel line condition, the interrelationship of the flow rate and the gas detection equipment capabilities, and other factors, could only be evaluated on a case by case basis. Accordingly, no change was made to this section.

Section 154.708. Proposed § 154.708(c) was changed so that it now follows the IMCO Gas Code which requires automatic closure of the master gas valve upon loss of inert gas pressure within a double-walled gas fuel piping system.

Section 154.709. The requirement is proposed § 154.709(a)(2) for automatic closure of the master gas valve upon detection of gas was changed to follow the IMCO Gas Code. The valve is required to close "before" (not "*if*" as proposed) the concentration reaches 3% by volume.

Cargo Vent Systems

Section 154.801. One commenter noted that proposed § 154.801(b) requires two relief valves of "equal capacity," while the IMCO Gas Code requires that they be only "approximately equal". This section has been rewritten to require two valves of "the same nominal relieving capacity."

One commenter questioned the requirement in proposed § 154.801(c)(1)

that the pressure relief valves meet 46 CFR Subpart 162.017 if the tank MARVS is 69 kPa gauge (10 psig) or less. He suggested that all pressure relief valves on gas carriers be required to meet 46 CFR Subpart 162.018 regardless of the tank MARVS. The intent of the proposal is that, when the cargo tank MARVS is 69 kPa gauge or less and the pressure relief device is also capable of vacuum relief, i.e. a P–V valve, the requirements of 46 CFR Subpart 162.017 may be met instead of 46 CFR Subpart 162.018. This section has been rewritten to clarify the intent.

Several persons commented on proposed § 154.801(c)(4) that the requirement to insulate the pressure relief valve from the cargo tank when carrying a cargo at a temperature below 0° C (32° F) is both impractical and unnecessary since these valves are designed for low temperature service. Further, they suggest that no material exists which will satisfy this requirement and also meet proposed § 154.522(b). The Coast Guard's intent in this section was to address the problem of the valves becoming inoperative due to ice formation. It is recognized that other alternatives are available to prevent this problem. Accordingly, proposed paragraph (c)(4) has been rewritten and moved into a new paragraph (d) in this section. The remaining proposed paragraphs were renumbered.

One commenter suggested that it be specified whether the required 0.015 L trim in proposed § 154.801(c)(5) is by the bow and stern or by the stern only. The proposed section has been rewritten to say that both trim by the bow and trim by the stern must be considered.

Section 154.804. Commenting on proposed § 154.804(a)(1), one commenter suggested that the audible and visual alarms for each tank be required only in the cargo control station. The Coast Guard agrees that a grouped alarm rather then independent alarms should be allowed in the wheelhouse. Requiring independent alarms in the wheelhouse for each tank provides no additional protection since no corrective action can be taken from this location. Accordingly, the section has been rewritten to reflect the comment. A definition of a "remote group alarm" is included in § 154.3.

Section 154.805. One commenter suggested that the provision contained in paragraph 8.2.10 of the IMCO Gas Code for vessels less than 90 meters in length be incorporated into proposed § 154.805(e) since it may be impractical to locate a vent mast 25 meters away from gas safe spaces on smaller ships. Another commenter suggested that the distance requirement stated in this proposed section, i.e. B or 25 meters whichever is less, is excessive in all cases. A distance of B or 25 meters is the required separation distance contained in paragraph 8.2.10 of the IMCO Gas Code and vessel designers have been able to meet this requirement. It is recognized, however, that on certain smaller vessels it may be impractical to locate vent masts B or 25 meters from gas safe spaces. Accordingly, this proposed section has been rewritten to allow shorter separation distances on vessels less than 90 meters in length if specially approved by the Commandant (G–MMT).

Section 154.806. One commenter suggested that proposed § 154.806 include specific reference to consideration of the anticipated inlet pressure losses to the relief valve to prevent resonant chattering of the valve, in addition to back pressure considerations when sizing the relief valves. Typical relief valve inlet nozzles on gas carriers could produce significant pressure losses if they are other than flush with the interior surface of the tank. Also, a long pipe riser (not usually used on gas carriers) or pipe bends could also produce this effect. When significant inlet pressure losses are present, it is expected that appreciable "resonant chattering of the valve" will occur. This is detrimental to the normal operation of the valve since it reduces the valve capacity and could potentially destroy the relief valve. The Coast Guard knows of no way in which "resonant chattering" can be prevented merely by sizing the relief valves. This effect can be eliminated, however, by proper design of the relieving arrangement so as to minimize inlet pressure losses to the relief valve. Accordingly, this problem has not been addressed in this section but is included in § 154.801 as a design consideration.

One person commented on this proposed section that when sizing the cargo tank relief valves the maximum capacity of the installed tank inerting system only becomes relevant if the maximum working pressure of this system exceeds the tank MARVS. The Coast Guard agrees with this comment and the section has been rewritten to reflect it.

Atmospheric Control in Cargo Containment Systems

Section 154.901. Several commenters questioned the need in proposed § 154.901(d)(1) for a gas sampling point at the middle of the tank. The IMCO Gas Code requires "sufficient" sampling points and the commenters report that sampling points at the top and the bottom of the tank have proven sufficient. One commenter stated that a sampling point in the middle of the tank required an additional line through the tank dome resulting in a potential decrease in safety. The Coast Guard accepts these comments and the requirement for the middle sampling point has been omitted.

Additionally, the words "gas freeing" have been removed from proposed paragraph (a). See the preamble discussion concerning proposed § 154.310.

Sections 154.902 and 154.903. One commenter suggested that the Coast Guard relax its dew point criteria in proposed §§ 154.902(c)(2), (d) and 154.903(b) since moisture is not detrimental to insulation applied to the inner hull rather than the cargo tank. The intent of these paragraphs is to limit the amount of water vapor in the atmosphere in these spaces. The Coast Guard agrees that the proposed dew point is too stringent, expecially in light of the fact that state-of-the-art inert gas generating equipment can only produce gas with dew points as low as approximately −50° C to −60° C. Also, at these temperatures moisture content in the gas is insignificant. For this reason, the Coast Guard has decided to change the dew point criteria so that the dew point of the inert gas or dry air admitted to the spaces must only be below −45° C (−49° F), or the lowest temperature of any surface in these spaces when the lowest surface temperature is warmer than −45° C (−49° F). This is the proposed dew point limit for gases admitted to cargo tanks carrying sulfur dioxide, see proposed § 154.1715. Accordingly, these changes were made to the subject paragraphs.

The proposal included six design or operation requirements for "inertion" of various components of the cargo containment system. These requirements can be found in proposed §§ 154.902(b), 154.1780, 154.1848(a)(4), and 154.1854(d). The sections, however, do not specify the concentration limits for flammable gas or oxygen that determine that a space is "inerted". The Coast Guard determined that the terms "inertion or inert atmosphere" are vague since they only indicate that the "inerted" space cannot support combustion. This is an extremely important safety consideration and should not be vague. Reviewing the available literature, most notably the "International Oil Tanker and Terminal Safety Guide (IOTTSG)", 2nd ed., 1974, the Coast Guard found that if a space contains less than 8–10% by volume

oxygen, combustion could not be supported. Hence the terms "inertion and inert atmosphere" could be construed as requiring any oxygen concentration from 8% by volume to as little as 0% by volume. For clarification, the Coast Guard has chosen to specify a maximum oxygen concentration for any space which is to be considered inerted. The value chosen was the IOTTSG's recommended value of 8% by volume O_2. Accordingly, the appropriate changes were made to the subject sections.

Section 154.904. Several commenters pointed out that the IMCO Gas Code only requires two check valves if the inert gas system is located in the machinery space or other space outside the cargo area. For inert gas systems located in other locations, one check valve is adequate for safety. The Coast Guard agrees with this comment and proposed § 154.904 is changed to require only one check valve in the inert gas system in the cargo area. A second check valve is required only when the inert gas system is located in the machinery space or other space outside the cargo area.

Section 154.908. Several commenters noted that proposed § 154.908 appears to rule out locating inert gas generators in the main machinery space, which was not intended by the IMCO Gas Code. The Coast Guard agrees with the comment and the wording in the section has been changed to allow the installation of inert gas generators in main machinery spaces.

Section 154.912. One commenter said that the method for sizing relief valves on inerted spaces should be specified in proposed § 154.912. The Coast Guard agrees, and plans to develop a criteria for sizing these safety devices to be proposed in a future issue of the **Federal Register.**

Electrical

Section 154.1010. One commenter suggested that it would be helpful to the operator if an additional alarm were provided to indicate loss of normal cargo pump pressure prior to the automatic shut-down that would be required under proposed § 154.1010(c)(1). The Coast Guard does not see a need to make this a requirement. It is noted, however, that the proposal does not prohibit such an alarm.

One commenter questioned whether proposed §§ 154.1010(j) and (k) apply to ammonia carriers under the applicability in § 154.1000(b). The Coast Guard thinks the wording of § 154.1000(b) is clear; for the purposes of §§ 154.1005 through 154.1020, an ammonia carrier is not gas-dangerous on the weather deck. Accordingly, paragraph (j) does not apply to ammonia carriers since it concerns zones on the open deck, and paragraph (k) may or may not apply depending on the particular spaces or areas involved.

Section 154.1015. One commenter suggested that in proposed § 154.1015 at least one the required two or more branch lighting circuits be supplied from the emergency power system. The Coast Guard has included such a requirement in a proposed revision of 46 CFR Subchapter J published in the June 27, 1977 issue of the **Federal Register** (42 FR 32700). Section 154.1015(a) is not changed since it does not prohibit the use of the suggested arrangement.

Firefighting System: Exterior Water Spray

Section 154.1110. Four comments were received concerning the meaning of proposed §§ 154.1110(a) and (d). It was felt that the proposed wording could be altered to more clearly define the requirement for water spray. Accordingly, paragraph (a) has been separated into new paragraphs (a) and (b) and the remaining proposed paragraphs renumbered. The definition of "other control valves" in proposed paragraph (d) has been changed to include only those valves "essential to cargo flow."

Section 154.1115. One comment was received questioning the technical justification of the 3.7 m (12 ft) limit for rundown on vertical surfaces in proposed § 154.1115. Experimental work at the Coast Guard's Fire & Safety Test Facility as well as work conducted at Southwest Research Institute has shown that water running down vertical surfaces will tend to "channel" or provide incomplete coverage after it has travelled a distance of 10–15 feet on bare steel. Section 4033 of NFPA STD. 15 "Water Spray Fixed Systems" also recommends 12 ft as a maximum vertical spacing for spray nozzles. Accordingly, the proposed spacing is correct.

During the review of this section, the Coast Guard determined that the proposed requirement for vertical spacing of nozzles could be misleading and should be located in § 154.1120. Accordingly, the requirement has been rewritten without changing the substance and moved to the appropriate section.

Section 154.1125. Four comments were received pertaining to proposed 154.1125. The commenters requested clarification of the purpose of paragraphs (b) and (e). Additional wording has been added to paragraph (b) to clarify the intent of the requirement, and paragraph (e) has been expanded into two paragraphs, (e) and (f).

Section 154.1130. One commenter requested an explanation of "the area of an athwartship tank grouping" in proposed § 154.1130. The Coast Guard agrees that an explanation should be incorporated into the requirement. A sentence was added to § 154.1130(a) to state what must be included in this area.

Section 154.1135. One commenter pointed out the fact that the Coast Guard had omitted the IMCO Gas Code requirement for an interconnection between the fire main and the water spray system. This is essential to provide a back up source of water for the spray system. This requirement was added to proposed § 154.1135(b).

Firefighting System: Dry Chemical

Sections 154.1140 to 154.1170. One general comment was received on the proposed regulations for dry chemical firefighting systems. The commenter suggested that the amount of fixed piping to a remote hose reel be limited to 300 feet. This comment was not accepted because all piped dry chemical systems are performance tested prior to approval. The maximum permissible amount of piping, which may be less than 300 feet, is determined at that time.

Section 154.1140. One commenter suggested that proposed § 154.1140 be expanded to include the Coast Guard requirements for dry chemical systems installed to protect gas fired boiler hoods. The Coast Guard agrees with the comment but at present does not require additional dry chemical protection in this area. This suggestion will be reviewed further and if regulations are warranted they will be published in a future notice of proposed rulemaking. Vessel owners may, however, install additional protection in these areas, subject to Coast Guard acceptance.

Proposed paragraph (b) has been removed and the requirement for the submission of plans of the dry chemical supply and distribution systems added as a new paragraph to proposed § 154.4. This change was made since the submission of plans for Coast Guard plan review applies only to U.S. flag vessels.

Section 154.1145. Two commenters expressed concern over proposed § 154.1145(d). The commenters felt that, as worded, the paragraph does not clearly define the 45 second operation requirements and should be reworded. Proposed paragraph (d) included design requirements for both the intended

operation of the dry chemical system and the quantity of dry chemical which must be stored. The Coast Guard agrees that confusion was possible since it was not obvious that both requirements were contained in the proposed paragraph. To clarify the wording proposed paragraph (d) has been replaced by new paragraphs (d) and (e) with the former containing the design operation requirement and the latter the design capacity requirement. Additionally, it should be noted that in paragraph (e) the design capacity requirement is the greater of either sequential or simultaneous operation; i.e., a 45 second requirement not a 90 second requirement as the proposal may have implied.

Section 154.1150. After reviewing proposed paragraph (a), the Coast Guard determined that the requirement for separate dry chemical supplies for hand hose lines and monitors exceeded the IMCO Gas Code. Accordingly, the requirement has been omitted.

Three comments were received concerning proposed § 154.1150(c). All of the commenters felt that the proposed requirement that at least one hose line or monitor to be located aft of the area being protected was in excess of the IMCO Gas Code, however, two of the commenters said that the requirements were logical and necessary, and supported them as written. The third commenter objected to the requirement on the basis that the requirement for separate dry chemical supplies in combination with the requirement of proposed paragraph (c) would serve to lower the effectiveness of the dry chemical firefighting system.

The Coast Guard agrees with the commenters that proposed paragraph (c) exceeds the IMCO Gas Code. This was not the intent of the Coast Guard and the proposed paragraph has been omitted. This requirement is currently being reviewed in detail, and if warranted an amendment to the Gas Code will be proposed to IMCO. At that time a change to U.S. regulations will also be proposed. This action, however, does not prevent the designers of liquefied gas vessels from employing such an arrangement if they feel it is necessary for improved dry chemical fire fighting protection.

Proposed paragraph (e) was omitted since the requirement is already covered by paragraph (a).

Section 154.1160. Two comments were submitted on proposed § 154.1160. One commenter suggested that a deflector or similar device be required on dry chemical monitors to preclude splashing at close ranges. Such a device is unnecessary because hand hose lines are provided for extinguishing fires of this nature. The second comment recommended that actual ranges be used in determining the coverage allowed for a monitor instead of using standard allowances. This comment cannot be adopted because a standardized test method for measuring this range is unavailable. Accordingly, these suggestions were not accepted.

Proposed paragraph (f) has been omitted since the Coast Guard determined that data extrapolation was not the intent of paragraph 11.4.6 of the IMCO Gas Code. Accordingly, the maximum allowable coverage for any dry chemical monitor, delivering 45 kg/sec or more, is 40 meters.

Section 154.1165. Proposed paragraph (a) has been changed to include hose cabinets as well as hose reels. The intent of this paragraph is to provide for the capability of remotely actuating (inert gas pressurizing and charging of hose line) the dry chemical storage unit from the site where the hose line is stored, whether it is a hose reel or hose cabinet. As proposed, the paragraph implied that only a hose reel could be used to store a hose. This was incorrect and has been corrected.

Six comments were received on proposed § 154.1165(b). The primary concern of these commenters was the intent of the "actuated and controlled" requirement for monitors. The intent of this paragraph was to require local actuation and control of all dry chemical monitors. In addition, those monitors for the cargo loading and discharge manifold must be capable of remote actuation and, except for pre-aimed monitors, remote control. Since pre-aimed monitors are pre-set to cover the manifold areas, it isn't necessary that they be capable of being controlled remotely, only locally. To clarify these requirements, proposed paragraph (b)(1), which contains the requirement for local control capability has been redesignated paragraph (b), and proposed paragraph (b)(2) rewritten and redesignated paragraph (c). The remaining paragraphs were renumbered accordingly.

Three commenters requested changes in proposed § 154.1165 (c) and (d) concerning the requirements for stop valves. It was recommended that, for those dry chemical fire fighting systems which do not have remote monitors and/or hose reels, stop valves were unnecessary. The Coast Guard concurs. Proposed paragraphs (c) and (d) were rewritten to require stop valves only where remote hand hose lines and monitors are installed and to clarify the requirements for operation of these stop valves.

Section 154.1170. Proposed paragraph (b) has been changed to require storage of the hose on either a hose reel or in a hose cabinet. This requirement was implied when proposed paragraph (b) and proposed § 154.1165(a) were considered. Other forms of hose storage could be accepted as equivalent under § 154.8.

Cargo Area: Mechanical Ventilation System

Section 154.1200. A change has been made to proposed § 154.1200(b)(2) to require supply-type mechanical ventilation only for those gas-safe cargo control stations located in the cargo area. If a cargo control station is located outside the cargo area the possibility of unexpected hazardous vapors entering the space is limited, and supply-type mechanical ventilation is no longer necessary.

Section 154.1205. Two commenters proposed that the required number of air changes for cargo control rooms suggested in proposed § 154.1205(d) be reduced if the space is adequately air conditioned. The intent of the ventilation system is to avoid the accumulation of flammable or toxic vapors and to ensure a safe working environment. Since air conditioning recycles the air in the space and introduces only a percentage of fresh air, it does not accomplish the intended purging of the atmosphere. This paragraph is in accordance with the IMCO Gas Code and the Coast Guard did not adopt the suggestion.

One commenter questioned whether or not the reference to § 154.703 in proposed § 154.1205(g) was relevant. The referenced section applies to gas burning which requires a mechanically ventilated pipe or duct for fuel gas lines that enter machinery spaces. The reference to § 154.703 is, therefore, relevant.

One commenter recommended that explosion-proof motors be permitted in the air stream. The requirement in proposed § 154.1205(h) is from the IMCO Gas Code and is consistent with attempts to minimize electrical equipment in hazardous areas. The Coast Guard did not accept the recommendation and the paragraph was not changed.

Section 154.1210. Commenting on proposed § 154.1210(a), one commenter requested that a definition of cargo piping be added to the rules, stating that without a definition § 154.1210(a) might require fixed mechanical ventilation in duct keels and void tanks containing

interbarrier drains and gas detection system piping. The Coast Guard has determined that a general definition of cargo piping would be impractical to incorporate into the regulations, as any incomplete definition would be both confusing and misleading to designers. In addition since the IMCO Gas Code does not include a definition of cargo piping and since the Coast Guard determined that adequate specifications and design criteria are already incorporated into U.S. regulations, the proposed change was not made.

After further review of proposed § 154.1210, it was determined that the wording of paragraph (a) was confusing. As proposed the requirement may be literally interpreted as requiring mechanical ventilation of hold spaces, void spaces and cofferdams only when these spaces contain cargo piping. This is incorrect. The Coast Guard's intent was to provide a means of mechanically ventilating these spaces whether or not cargo piping was installed in them, and also to require a means of mechanically ventilating any other space containing cargo piping. To eliminate this possible confusion the wording of proposed paragraph (a) has been changed.

Instrumentation

Section 154.1305. One commenter noted that a literal interpretation of proposed § 154.1305(a) would not require level gauge operation until a pressure equal to the MARVS was reached. The Coast Guard agrees with this comment and the section was changed to require that the level gauge be operable at pressures up to and including the MARVS.

One commenter indicated that proposed § 154.1305(b) contained no design standard that a secondary level gauge would have to meet. The Coast Guard agrees with this comment and the section was changed to require the secondary level gauge to comply with the same standard as a primary gauge.

One commenter requested that in proposed § 154.1305(b), consideration be given to allowing the use of separate probes, one at the top and one at the bottom of the tank, in lieu of a full height probe for the redundant liquid level gauge. The Coast Guard did not accept this comment because the alternative is not considered as equivalent to the required arrangement.

Several commenters objected to the requirement in proposed § 154.1305(c) that level gauges be capable of measuring liquid levels as low as 100 mm (4 inches), stating that it was not within the capability of devices specifically included as acceptable for this application. Because other Coast Guard regulations provide for both thermal detection of cargo in the tank bottom and automatic cargo pump low liquid level shutdown, this section was changed to include a new lower limit of 400 mm (16 inches). This value was determined to be the minimum liquid level which could be detected by all devices which are listed as acceptable to the Coast Guard in § 154.1300. Additionally, the term "tank bottom" was changed to "lowest point in the tank," to avoid confusion when considering spherical tanks.

A correction has been made to proposed §§ 154.1300, 154.1305 and 154.1325. As proposed these sections implied that the full range of liquid levels in the cargo tank must be measured by *one* liquid level gauge. This was not the Coast Guard's intent nor the intent of paragraph 13.2.1 of the IMCO Gas Code. The intent of the Coast Guard was to ensure that any liquid level, from 400 mm from the tank bottom to 100% full, could be measured. It is recognized that devices or systems which are acceptable for this task may consist of more than *one* liquid level gauge, for instance, one gauge measuring from 400 mm to 55% full and a second gauge measuring from 50% to 100% full, rather than only one gauge measuring the full range. To clarify the Coast Guard's intent, the term "liquid level gauges" has been replaced by the term "liquid level gauging systems" wherever it appeared in proposed §§ 154.1300, 154.1305 and 154.1325.

Section 154.1315. One commenter noted that a literal reading of proposed § 154.1315 would allow multiple openings for each gauging device. The Coast Guard agrees with this commenter, and the section was changed by omitting the redundant requirement and referring to the section that contains the requirement, § 154.536.

Section 154.1325. Two commenters suggested that proposed § 154.1325 did not allow the alarm (paragraph (b)) and shut-down (paragraph (c)) functions of the high liquid level alarm to be actuated by separate sensors as in paragraph 13.3.1 of the IMCO Gas Code. The intent of the Coast Guard was to require that both alarm and shutdown be available and be *automatically* actuated to prevent the tank from becoming 100% liquid full. This can be accomplished by one or two sensors at the designer's discretion. The commenter's confusion may have resulted from the use of the term "high liquid level alarm" in both the title and introductory remarks of proposed § 154.1325, since this term implies a single component. To clarify the Coast Guard's intent in this section, the term has been changed to "high liquid level alarm system" in both places.

Proposed paragraphs (b) and (c) have also been changed. In proposed paragraph (b), the high liquid level alarm system is intended as a last line of defense against overfill, and as such, the alarm should be set to sound prior to, or when, closing of the flow shut-down values begins. This correction has been made to proposed paragraph (b).

Finally, the intent of paragraph (c) is to prevent overfill of the cargo tanks without causing damaging pressure surges in the cargo loading lines, hence stopping the flow of cargo to the tank is the most important consideration. Proposed paragraph (c) requires that this be accomplished via actuation of quick-closing valves, however, the Coast Guard recognizes that other methods may perform equally well. For this reason a change has been made to this paragraph by adding actuation and closure of a stop valve in the cargo loading line as another acceptable method of preventing tank overfill. It should be further noted, that variables such as valve closing time and cargo loading rate, must be considered when determining the tank liquid level at which closure begins.

Section 154.1340. Several commenters questioned the requirement in proposed §§ 154.1340 (c)(3) and (c)(4) for the display of temperature readings at regular intervals while underway, since the cargo control station would be normally unmanned. This proposed requirement follows paragraph 13.5.2 of the IMCO Gas Code, except that intervals of one hour or less were proposed in this paragraph to define "regular intervals". Additionally, proposed paragraph (c)(4) of this section was changed to require a "remote group alarm" in the wheelhouse. This was done to ensure that a warning was available in a manned location.

One commenter noted that proposed § 154.1340(e) required devices for initial verification of the cool down procedure, on *one* tank of the first vessel of a class of vessels, which are in addition to those required by paragraph (d). This ignores the situation where *all* of the tanks are instrumented with more than the minimum number of devices required in paragraph (d). In this case, the number of devices satisfying paragraph (d) may also satisfy paragraph (e), but, using a literal translation of paragraph (e), more devices must be added to one tank. This was not the intent of the Coast Guard, and proposed paragraph (e) has been

changed to remove the requirement for "additional" devices.

After further review the Coast Guard determined that this proposed paragraph was not a design requirement but rather specifies the equipment necessary to test, and thereby verify, the proposed cool down procedure. As such this paragraph was removed from this section and placed in proposed Subpart B—Tests and Inspection, as a new section 154.65. Additionally, no consideration was given when the same tank design is used in another class of vessels. This consideration was also incorporated into new § 154.65. As stated above Subpart B will be published in a future issue of the **Federal Register**.

Section 154.1345. Proposed § 154.1345(c) has been changed to exclude all gas-safe spaces from housing fixed gas detection systems for the two extremely toxic cargoes; methyl bromide and sulfur dioxide. This paragraph now follows paragraph 17.11.1 of the IMCO Gas Code. Additionally, since methyl bromide is flammable (see Table 4–Summary of Minimum Requirements), proposed § 154.1340 requires a fixed flammable gas detector meeting § 154.1350. Proposed paragraph (c)(1) is therefore redundant with respect to the carriage of methyl bromide, and has been changed such that it now applies only to the carriage of sulfur dioxide.

Section 154.1350. One commenter suggested that the requirement for gas detection in boiler vent hoods be included in proposed § 154.1350(a). The Coast Guard does not agree with this suggestion because this consideration is specifically included in §§ 154.706 and 154.709.

Several commenters requested clarification of proposed § 154.1350(a)(5) with regard to whether cargo area ballast tanks are included in the term "other enclosed spaces". This section was changed to clarify that ballast tanks are exempt from fixed gas detection requirements.

One commenter noted that proposed § 154.1350(c) was not consistent with proposed § 154.1350(m) in that it did not include the wheelhouse as an acceptable location for gas detection equipment and piping runs. The Coast Guard agrees, however, the location intended was that gas-safe space where the gas detector was housed. Since this location may be a gas-safe space other than the wheelhouse or gas-safe cargo control station, proposed paragraphs (c) and (m) have been changed to indicate the correct locations. A new paragraph was included at § 154.1350(d) that requires each gas detection system to have a readout. The remaining paragraphs were renumbered accordingly.

One commenter indicated that proposed § 154.1350 (e) and (g) were not clear with regards to where visual alarms, traceable to the alarmed space, were required. These alarms are only required in the space where the gas detection system's readout is located. A "remote group alarm", as defined in § 154.3, is acceptable in other areas, such as the wheelhouse or cargo control station when the gas detector readout is not located there, since in those areas it is only important to know that an alarm condition exists. Proposed paragraphs (e) and (g) have been changed to clarify this intent and renumbered (g) and (h) respectively.

Commenting on proposed § 154.1350(j), one commenter questioned the technical necessity for protection of gas sampling lines with flame arrestors. The flame arrestors are intended to prevent flame propagation to the tanks via the sampling tubes not to protect the sampling lines themselves. The wording in this paragraph was changed to reflect this intent and the paragraph was renumbered paragraph (k).

Several commenters felt that in proposed § 154.1350(s) the requirement for a flow meter in each sampling line was unnecessary, and that a common meter would suffice. The purpose for requiring flow indication in each line is to enable the operator to ensure that gas is not flowing from one space to another; i.e., back flow from a gassy space at high pressure to a gas free one at a lower pressure. This paragraph was changed to permit the installation of only one meter in the system, but to require an individual indication of flow in each sampling line.

Proposed paragraph (t) has been changed to require a different concentration range to be detected. As proposed, the detection system must be capable of measuring gas concentrations of 0–100% of the lower flammable limit (LFL), while alarming at or below a concentration of 30% of the LFL (proposed paragraph (d)). The Coast Guard recognizes that for the carriage of toxic-flammable cargoes, a more important alarm concentration may be the threshold limit value (TLV) of the cargo rather than 30% of the LFL. For all of the cargoes that are considered to be toxic under this rule, the TLV is significantly less than the LFL, i.e. ppm concentrations vs. percentage concentrations, hence, the requirement to alarm at or below 30% of the LFL is always satisfied. The Coast Guard further recognizes that to require a detector to both alarm at parts per million concentrations and to measure 0–100% of the LFL could significantly reduce the precision of the equipment and the resulting accuracy of the alarm setting, while not increasing the level of safety. Due to these considerations the Coast Guard has changed proposed paragraph (t) to require that the detector be capable of measuring gas concentrations of at least 0–200% *of the alarm condition*, rather than 0–100% of the LFL.

Section 154.1365. Commenting on proposed § 154.1365(c), one commenter asked whether all alarm locations, including remote locations, were required to show the space in which a fault exists. This paragraph was changed to clarify that "remote group alarms" need not identify the space in which the alarm condition exists.

Sections 154.1370, 154.1375. Commenting on proposed §§ 154.1370 and 154.1375, one commenter stated that marking of limits on indicating devices was applicable to analog devices only and not to digital devices. The Coast Guard did not change these sections since the marking requirement is applicable to both types. For a digital device, compliance could be achieved by providing a label, sign, or other indication of operating limits on or near the face of the display.

Safety Equipment

Section 154.1400. One commenter noted that proposed § 154.1400(a)(1) required six self-contained breathing apparatus for vessels less than 25,000 m^3, whereas the IMCO Gas Code only required five. The IMCO Gas Code requires vessels of under 25,000 m^3 to have three sets of fireman's protective clothing (paragraph 11.6.1) and three sets of safety equipment (section 14.3), each set containing a self-contained breathing apparatus; therefore, six apparatus is correct.

Another commenter suggested that a more appropriate division than over or under 25,000 m^3 could be found. IMCO is currently considering revising the Code requirements as a result of proposals similar to the commenter's. However, the regulations in Part 154 follow the IMCO Gas Code, which uses 25,000 m^3. Amendments to Part 154 will be proposed when revisions are made to the Code.

Two commenters said that "chemical protective outfits" should be defined in proposed § 154.1400(b)(10). The intent of this regulation was to require clothing that would protect the wearer against the hazards of the cargo. As one commenter pointed out, for methane,

ethane, propane and butane, the principal hazard is fire and, therefore, the "chemical protective outfits" may be the same type of clothing as the "fireman's protective outfits". For other cargoes, such as sulfur dioxide, the hazard that the clothing is to protect against would be corrosivity. The wording of this section has been changed to make it clear that the clothing is to protect the wearer against the particular personnel hazards presented by the cargo vapor.

One commenter questioned whether or not the equipment required in proposed § 154.1400 was in addition to or in lieu of that required by 46 CFR 35.30–20. The equipment required by § 154.1400 is considered to exceed and, therefore, to fulfill, the requirements of 46 CFR 35.30–20. Proposed paragraphs (a) and (b) have been reworded to clarify this requirement, and proposed § 154.1800 has been changed to omit compliance with § 35.30–20.

Finally, proposed §§ 154.1400 (a)(1), (b)(1) and (c)(1) have been changed in order to clarify the type of breathing apparatus that are acceptable to the Coast Guard.

Section 154.1405. One commenter stated that the respiratory protection equipment required in proposed § 154.1405 should be permanently located at other places in addition to those required to be stored in the wheelhouse. The Coast Guard feels the stowage and distribution of the required equipment, other than the two required to be in the wheelhouse, is the vessel operator's purview. Accordingly, this suggestion was not accepted. Proposed paragraphs (a) and (b) were changed, however, in order to clarify the level of protection that is required of this equipment.

Section 154.1420. One commenter stated that it is not clear in proposed § 154.1420 as to what type of equipment is required. This equipment must provide a means for effectively removing an injured person from a cargo tank. Any device which reasonably accomplishes this task is acceptable. The Coast Guard does not intend to prescribe specifications for this device at this time.

Another commenter asked what is intended other than to recognize that facilities must be available to remove an injured person. Nothing else is intended by this section other than the effective removal of an injured person.

Section 154.1425. Proposed § 154.1425 has been omitted because the Coast Guard is in the process of developing a proposed rule covering safety equipment common to all tank vessels. This rule will be proposed in a future Federal Register.

Special Design and Operating Requirements

Section 154.1710. See the preamble comments concerning proposed § 154.902.

Sections 154.1725 and 154.1730. Two questions were received on the requirements for propylene oxide. Propylene oxide is presently regulated under 46 CFR Part 153 (42 FR 49016) because it is a liquid chemical. IMCO is considering the addition of propylene oxide and six other high vapor pressure chemicals to the Gas Codes. When these additions are made, the Coast Guard will consider similar revisions to Part 154.

During the development of proposed §§ 154.1725 and 154.1730 for ethylene oxide, the Coast Guard inadvertently omitted two existing requirements contained in 46 CFR 40.05–83 (b) and (d). The first special requirement, 46 CFR 40.05–83(b), deals with the inertion of the vapor space of a cargo tank containing ethylene oxide. For the other flammable cargoes regulated by Part 154, inertion is used to reduce the oxygen level below the minimum necessary to form a flammable mixture. For ethylene oxide, however, this is not the only consideration since this product contains its own oxidizer. While proposed § 154.1730(a)(2) and 17.2.1(b) of the IMCO Gas Code both require inertion of the vapor spaces, neither specifies the extent of inertion necessary to ensure that the ethylene oxide vapor is non-flammable. To ensure this, the vapor space must be inerted to at least 45% nitrogen by volume. This value is the same as the existing special requirement in 46 CFR 40.05–83(b). This consideration has been added to § 154.1725. The Coast Guard will propose this correction to IMCO.

Second, the Coast Guard inadvertently omitted the existing special requirement, 46 CFR 40.05–83(d), that for ethylene oxide carriage the water spray system must also protect the above deck cargo piping. The requirement has been added at § 154.1725(a)(7) to correct that omission.

Section 154.1735. Since the publication of this proposal, a new composition for methyl acetylene-propadiene gas mixtures was specially approved for carriage on liquefied flammable gas vessels. This composition was added to this section as a new paragraph (a)(2). The requirements for the carriage of this new composition are the same as for the original composition proposed.

The methyl acetylene-propadiene mixture composition originally proposed in § 154.1735 was in error. Corrections have been made to proposed paragraphs (a)(3) and (a)(4) and proposed paragraph (a)(5) has been omitted. This corrected composition now reflects the mixtures currently being authorized for carriage by the Coast Guard. Additionally, certain other requirements in proposed § 154.1735 were rewritten for clarification.

Section 154.1755. One commenter suggested that proposed § 154.1755 would be clearer if worded "Nitrogen cargo containment systems and piping systems on vessels carrying nitrogen in other than deck tanks must be specially approved by the Commandant (G–MMT)". Wording similar to the suggested wording was incorporated.

Section 154.1760. One commenter noted that the prohibition in paragraph 17.12.4 of the IMCO Gas Code against spraying ammonia into a tank containing air was omitted. There is considerable doubt that static discharge is a valid concern with commercial anhydrous ammonia, although there is some scientific data to indicate it could be with pure, laboratory grade ammonia. This question is being considered at IMCO, and the Coast Guard agrees that until the question is resolved safety demands that the conservative approach be adopted as the prohibition stated in paragraph 17.12.4. Accordingly, a new section containing this prohibition is added at § 154.1760. For further discussion see the preamble comments for proposed § 154.902.

Operations

Sections 154.1800–154.1870. One commenter suggested that the words "Cargo Officer or" be added to the phrase "the master shall ensure" wherever it appears in proposed § 154.1812 through § 154.1870, so that either the master or cargo officer would be responsible for those operating requirements. The proposed wording of these sections does not prevent the master from delegating those duties to the cargo officer and not actually doing them himself. However, for these requirements the master always must bear the ultimate responsibility for the safety of his ship even if he has delegated certain duties to others. The Coast Guard rejected the comment.

For clarification, a new section has been added at § 154.1831 to specify that it is the responsibility of the master of the vessel to designate one individual as the "person in charge of cargo transfer."

Section 154.1802. This proposed section was rewritten for clarification and to add the Cargo Ship Safety Construction and Equipment Certificates to the list of plans and certificates which must be maintained onboard the vessel. The requirement that the Certificates be carried onboard was transferred from existing 46 CFR Part 154. Proposed § 154.1802 is now §§ 154.1801 and 154.1802.

Section 154.1803. A new section was added to the proposal indicating that a Letter of Compliance is valid for a period not exceeding two years. For further discussion, see the "miscellaneous" preamble comments.

Section 154.1810. One commenter requested that specific reference to the loading and stability manual be made in proposed § 154.1810(b)(17) to insure that the "operational means" were clearly defined. The Coast Guard concurs and has changed the regulation.

One commenter stated that the inclusion of "cargo jettisoning system" in proposed § 154.1810(b)(9)(xi) raises a new subject not discussed elsewhere in the regulations. Sections 154.310, 154.350 and 154.1725(e) address that system.

Since vessels with IMCO Certificates will have cargo manuals accepted by their flag administration, they have been excluded from the applicability of this section.

Section 154.1814. One commenter asked if the information cards required in proposed § 154.1814 were the cards published by the Manufacturing Chemists Association (MCA). Those cards would satisfy the requirements in § 154.1814, but the cards do not necessarily have to be MCA cargo information cards. The commenter further stated that on cards such as the MCA card, the procedures to follow in the event of "equipment breakdown" would be too lengthy. Since this information would be included in the cargo manual required in § 154.1810, the words "equipment breakdown" have been omitted from § 154.1814.

Section 154.1828. Two commenters suggested that proposed § 154.1828 be omitted because it is not practical or necessary. The proposed requirement does not mean that each and every time someone enters a pump room, for example, he must receive specific approval of the master and that the master has personally tested the atmosphere of the space. It does mean, however, that the master has procedures for ensuring the safety of his crew and that approval for personnel to enter cargo handling spaces is given under certain conditions. The wording has been changed to indicate that following a procedure established by the master is acceptable.

Section 154.1836. Some commenters questioned whether proposed § 154.1836 applied to operation of relief valves and restricted gauges. As stated in the preamble of the proposal, the IMCO Gas Code allows pressure and temperature control of cargoes by venting of cargo vapors in port if accepted by the "receiving administration". The intent of § 154.1836 was to serve notice that the Coast Guard, representing the receiving administration, would not accept this means of cargo temperature/pressure control in U.S. waters. The prohibition was not intended to apply to vapor releases by relief valves under abnormal conditions, such as fire, nor to small releases of cargo vapor through restricted gauges. The wording in proposed § 154.1836 was modified to clarify this intent.

One commenter stated that cargo is routinely vented to atmosphere when disconnecting cargo hoses. The Coast Guard does not concur. Nitrogen purge connections are specifically installed to prevent this from occurring when disconnecting loading arms and cargo hoses.

One commenter requested clarification of proposed § 154.1836 by the specification that it is limited to U.S. ports. As discussed above the prohibition applies to all U.S. waters.

Section 154.1840. In agreement with a comment, proposed § 154.1840 has been changed to exclude those persons assigned to gas safe cargo control rooms during the cargo transfer operation from the requirements to wear protective clothing since they will not be exposed to the hazards of the cargo in their regular duties.

Section 154.1842. One commenter questioned whether the intent of proposed § 154.1842 was to require activation of the test controls for the alarms or to actually create an alarm condition to see if the alarm worked. The intent is to test the alarms by means of a test control or other simulation of the alarm condition.

It was also questioned whether the proposed section meant all alarms or just those for high liquid level. The wording has been changed to make it clear that the test is a simulated overfill condition and that the liquid level alarm required under § 154.1325 is tested.

Section 154.1844. One commenter thought that the 98% maximum filling limit applied to all tanks. As proposed in § 154.1844(a)(2), a higher limit would be accepted if specified on the IMCO Certificate of Fitness or the Certificate of Inspection. The higher limit would be allowed if it could be shown that, due to the shape of the tank, arrangement of relief valves, accuracy of level and temperature gauging, and other conditions, the tank level will drop during operation of the relief valve and the relief valve will not be exposed to liquid. The Coast Guard agrees that confusion could have resulted and has changed the wording in this section to clarify the intent.

Section 154.1848. Commenting on proposed § 154.1848, one commenter suggested that some flexibility be provided concerning the inerting requirements during shipboard maintenance and repair. It is assumed that the intent of this suggestion is to permit hold and interbarrier spaces, which are normally inerted, to be filled with air to allow personnel to enter them while gas is in the tanks. The Coast Guard does not accept the suggestion since this compromises the safety of the vessel.

See the preamble comments concerning proposed § 154.902.

Section 154.1854. Two commenters recommended that in proposed § 154.1854(a) "pilot fuel oil burner" be changed to "fuel oil fired pilot" as some dual fuel burners are designed for a minimum oil flow at all times and no separate pilot fuel oil burner exists. The Coast Guard concurs and has amended the regulations accordingly.

One commenter requested that the words "Chief Engineer" be inserted for "Master" in this section. The Coast Guard does not concur. The Master has the ultimate responsibility to ensure that this section is met.

See the preamble comments concerning proposed § 154.902.

Section 154.1856. This proposed section has been omitted pending publication of Subpart B of this proposal. For further discussion, see the preamble comments for Subpart B—§§ 154.40 through 154.149.

Section 154.1858. One commenter said that a master would have no way of knowing the prior history of hoses and therefore it is inappropriate in proposed § 154.1858 to impose this responsibility on the master, particularly if the cargo hose is provided by a shore facility. As stated in the preamble discussion to proposed §§ 154.552–154.562, the Coast Guard is not attempting to set standards for shore facility equipment in these vessel regulations. However, for cargo transfer operations, the use of cargo hose necessitates interfacing between the shore facility and the vessel. For safety, the Coast Guard wants to ensure that only cargo hose meeting the minimum standards of this part or

equivalent standards is used during cargo transfer. Since this rule applies only to vessels, the responsibility under these regulations must be exercised by ship's personnel. Therefore, for cargo transfer, the person in charge must ensure that either the vessel's cargo hose is used or hose meeting equivalent standards is obtained from the shore facility.

Based upon the above comment and after further review, the Coast Guard determined that proposed § 154.1858 needs clarification. The intent of this section was to ensure that only cargo hose meeting the standards of this part or equivalent standards be used for cargo transfer. Further, the proposed prohibition should be an equipment requirement rather than an operating requirement. To clarify the Coast Guard's intent in this section, the proposed prohibition has been moved to § 154.560, where prototype testing of cargo hose is addressed, and § 154.1858 rewritten to reflect the correct operating requirement.

Section 154.1872. A new section was added at § 154.1872 to include the operational requirements for cargo jettisoning. For further discussion see the preamble to § 154.310(d).

Table 4. Summary of Minimum Requirements

Two commenters noted that chlorine was not included in proposed Table 4 although it is listed in the IMCO Gas Code. This chemical is not listed in Table 4 because the Coast Guard does not allow the bulk shipment of chlorine on manned vessels.

The ommission, in proposed Table 4, of other cryogenic liquefied gases, such as helium and hydrogen, was questioned. These cargoes are not included in the IMCO Gas Code, nor are they under current Coast Guard regulations for bulk shipment. If other liquefied gases are proposed for bulk shipment, safe carriage requirements will be developed and proposed if it is determined that they may be safely carried in bulk. For further discussion, see the preamble for "Miscellaneous" comments.

General Comments

Besides the changes to the original proposal which are described in this preamble, many typographical errors were corrected.

The Coast Guard has determined that the proposed regulations would have no foreseeable significant impact on the quality of the human environment. An environmental assessment with a negative declaration has been prepared. Copies may be obtained in Room 8117, Coast Guard Headquarters, Washington, D.C. 20590.

The economic evaluation for this proposal shows that for each of the next seven fiscal years the proposed regulations would result in the following:

(1) A decreased expenditure of about $0.2 million by the Federal government, and no significant impact on state and local governments. The cost savings to the Federal government resulted from decreased manpower requirements, both professional and clerical, and reductions in estimated travel expenses.

(2) An increased cost of $21.6 million to consumers, businesses and industry. The increased cost primarily impacts the maritime industry and results from the need for improved ship construction and equipment necessary to meet the upgraded safety standards of this rule. These costs are eventually passed on to the consumer.

(3) No significant impact on energy consumption, important materials or employment.

The benefits to the public of the proposal include:

(1) A consolidation into one part of design and equipment regulations for various liquefied gas ships.

(2) Incorporation of an internationally agreed upon standard for liquefied gas ships with clarification, where possible, of portions of that standard (the IMCO Gas Code) that are left to "the satisfaction of the Administration."

(3) Codification of existing and additional requirements for the design, construction and operation of liquefied gas ships.

A quantitative analysis of the benefit to the public is difficult to access due to the excellent safety record of liquefied gas ships. However, it is clear that the adoption of an international standard, that further increases the level of safety of gas ships, is beneficial to the public interest. U.S. gas ship owners and operators will benefit by having an internationally accepted Certificate to facilitate their vessel's operation in foreign ports.

This rule has been reviewed under Department of Transportation's "Policies and Procedures for Simplification, Analysis, and Review of Regulations" (43 FR 9582, March 8, 1978). A final evaluation has been prepared and is included in the public docket.

In consideration of the foregoing, the proposed rules published in the October 4, 1976 issue of the Federal Register (41 FR 43822) are hereby adopted with the changes described above and set forth below.

Chapter 1 of Title 46, Code of Federal Regulations, is amended as follows:

PART 31—INSPECTION AND CERTIFICATION

1. By amending Part 31 by adding § 31.10–18a to read as follows:

§ 31.10–18a Liquefied gas vessels: additional firefighting equipment inspections.

(a) Once during each 12 month period after the month an original Certificate of Inspection is issued for a liquefied gas vessel under § 31.05–1, the master shall ensure that the firefighting systems required in Part 154 of this chapter for a liquefied gas vessel meets the following:

(1) The exterior water spray system must past a water spray test.

(2) The dry chemical system must meet the manufacturer's specifications for—

(i) The amount of dry chemical powder; and

(ii) The pressure for nitrogen bottles.

(3) The piping, valves, and controls of the system must be operable.

(b) On the same date that the requirements under paragraph (a) of this section are met, the master shall record in the vessel's official logbook the following information:

(1) The date of the inspection.

(2) The identification of each device inspected.

(3) The name of the inspector.

PART 34—FIREFIGHTING EQUIPMENT

2. By adding new text at the end of paragraph (b) of § 34.10–15 and after the words "approximately" and "50 pounds per square inch" in paragraph (c) of the same section to read as follows:

§ 34.10–15 Piping-T/All.

* * * * *

(b) * * * except on self-propelled vessels carrying bulk liquefied gases that must have stop valves—

(1) at cross connections;

(2) at the front of the after deck house: and

(3) in the cargo area spaced 40 m (131 ft.) or less between hydrants.

* * * * *

(c) * * * 71 pounds per square inch on self-propelled vessels that carry bulk liquefied gases and approximately * * * on other tankships.

* * * * *

PART 40—SPECIAL CONSTRUCTION, ARRANGEMENT, AND OTHER PROVISIONS FOR CARRYING CERTAIN FLAMMABLE OR COMBUSTIBLE DANGEROUS CARGOES IN BULK

§ 40.05 [Revoked]

4. By revoking Subpart 40.05.

PART 54—PRESSURE VESSELS

By amending § 54.15–25 by revising paragraph (c) and adding paragraph (c–1) to follow paragraph (c) to read as follows:

§ 54.15–25 Minimum relief capacities for cargo tanks containing compressed or liquefied gas.

* * * * *

(c) The rate of discharge for heat input of fire must meet the following formula:

$Q = FGA^{0.82}$

Where:

Q = minimum required rate of discharge in cubic meters (cubic feet) per minute of air at standard conditions 0° C and 1.03 kp/cm² (60° F and 14.7 psia).

F = fire exposure factor for the following tank types:

F = 1.0 for tanks without insulation located on the open deck.

F = 0.5 for tanks on the open deck having insulation that has approved fire proofing, thermal conductance, and stability under fire exposure.

F = 0.5 for uninsulated independent tanks installed in holds.

F = 0.2 for insulated independent tanks in holds or for uninsulated independent tanks in insulated holds.

F = 0.1 for insulated independent tanks in inerted holds or for uninsulated independent tanks in inerted, insulated holds.

F = 0.1 for membrane and semi-membrane tanks.

G = gas factor of:

$$G = \frac{177}{LC}\sqrt{\frac{ZT}{M}} \qquad \left(G = \frac{633,000}{LC}\sqrt{\frac{ZT}{M}}\right)$$

Where:

L = latent heat of the material being vaporized at the relieving conditions, in Kcal/kg (Btu per pound).

C = constant based on relation of specific heats (k), Table § 54.15–25 (c) (if k is not known, C = .606 (315)).

Z = compressibility factor of the gas at the relieving conditions (if not known, Z = 1.0).

T = temperature in degrees K = (273 + degrees C) (R = (460 + degrees F)) at the relieving conditions (120% of the pressure at which the pressure relief valve is set).

M = molecular weight of the product.

A = external surface area of the tank in m² (sq. ft.) for the following tank types:

For a tank of a body of revolution shape:

A = external surface area.

For a tank other than a body of revolution shape:

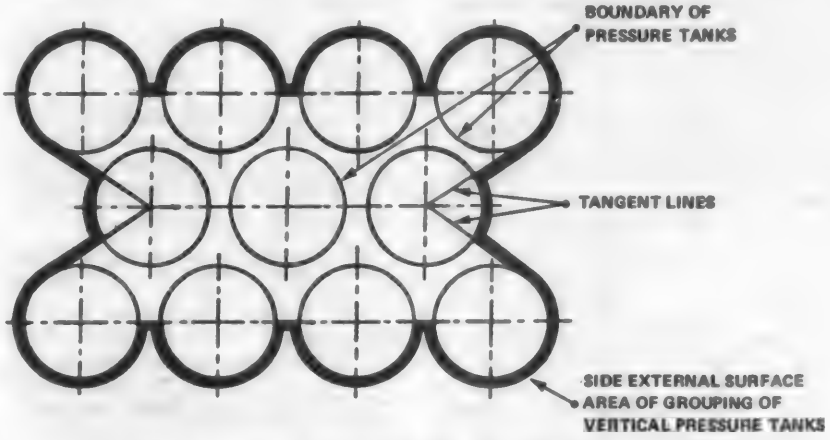
A = external surface area less the projected bottom surface area.

For a grouping of pressure vessel tanks having insulation on the vessel's structure:

A = external surface area of the hold without the projected bottom area.

For a grouping of pressure tanks having insulation on the tank:

A = external surface area of the pressure tanks excluding insulation, and without the projected bottom area.[1]



SIDE EXTERNAL SURFACE AREA OF GROUPING OF VERTICAL PRESSURE TANKS

Figure 54.15–25 (c)

Table 54.15–25 (c)–*Constant C*

k	C	
1.00	.606	(315)
1.02	.611	(318)
1.04	.615	(320)
1.06	.620	(322)
1.08	.624	(324)
1.10	.628	(327)
1.12	.633	(329)
1.14	.637	(331)
1.16	.641	(333)
1.18	.645	(335)
1.20	.649	(337)
1.22	.652	(339)
1.24	.656	(341)
1.26	.660	(343)
1.28	.664	(345)
1.30	.667	(347)
1.32	.671	(349)
1.34	.674	(351)
1.36	.677	(352)
1.38	.681	(354)
1.40	.685	(356)
1.42	.688	(358)
1.44	.691	(359)
1.46	.695	(361)
1.48	.698	(363)
1.50	.701	(364)
1.52	.704	(366)
1.54	.707	(368)
1.56	.710	(369)
1.58	.713	(371)
1.60	.716	(372)
1.62	.719	(374)
1.64	.722	(376)
1.66	.725	(377)
1.68	.728	(379)
1.70	.731	(380)
1.72	.734	(382)
1.74	.736	(383)
1.76	.739	(384)
1.78	.742	(386)
1.80	.745	(387)
1.82	.747	(388)

Table 54.15–25 (c)–*Constant C*

k	C	
1.84	.750	(390)
1.86	.752	(391)
1.88	.755	(392)
1.90	.758	(394)
1.92	.760	(395)
1.94	.763	(397)
1.96	.765	(398)
1.98	.767	(399)
2.00	.770	(400)
2.02	.772	(401)
2.20	.792	(412)

(c–1) For an independent tank that has a portion of the tank protruding above the open deck, the fire exposure factor must be calculated for the surface area above the deck and the surface area below the deck, and this calculation must be specially approved by the Commandant (G–MMT).

* * * * *

§ 54.25–10 [Amended]

5. By amending § 54.25–10 as follows:

a. In paragraph (a)(1), by striking the words "in Subchapter D (tank vessels)" and inserting the reference "and § 154.3" in place thereof after the reference "§ 38.05–4".

[1] Figure 54.15–25(c) shows a method of determining the side external surface area of a grouping of vertical pressure tanks.

b. In paragraph (b)(1)(i) by striking "−70° F" and inserting "−67° F" in place thereof.

c. In table 54.25–10 (b)(1) in the column entitled "Minimum service[1] temperature ° F", by striking "−70" and inserting "−67" in place thereof, and in the column entitled "Manganese range[1] percent" by striking "0.90" and inserting "0.70" in place thereof, and by striking "1.65" and inserting "1.60" in place thereof.

d. By striking the columns following footnote 1 of table 54.25–10 (b)(1) and inserting the following two columns in place thereof:

	Range percent
Si	0.10–0.50
	Maximum
S	0.035
P	0.035
Ni	0.80
Cr	0.25
Mo	0.08
Cu	0.35
Nb	0.05
V	0.08

e. In the second line of paragraph (b)(2), by striking "–70° F" and inserting "–67° F" in place thereof.

PART 56—PIPING SYSTEMS AND APPURTENANCES

§ 56.50–105 [Amended]

6. By striking in the second sentence in § 56.50–105 (a) the words "Subchapter D (Tank Vessels) and I (Cargo and Miscellaneous Vessels)" and inserting "Subchapters D, I, and O" in place thereof.

PART 98—SPECIAL CONSTRUCTION, ARRANGEMENT, AND OTHER PROVISIONS FOR CERTAIN DANGEROUS CARGOES IN BULK

7. By revising § 98.25–1 to read as follows:

§ 98.25–1 Applicability.

(a) The regulations in this subpart apply to each self-propelled vessel that has anhydrous ammonia on board as a cargo, cargo residue, or vapor and that is not regulated under Part 154 of this chapter.

(b) Any self-propelled vessel to which this subpart applies shall be inspected and certificated under this Subchapter and Subchapter D of this chapter.

PART 154—REDESIGNATED AS PART 154a

PART 154a—REDESIGNATED FROM PART 154 AND AMENDED

8. By redesignating Part 154 as Part 154a and amending new Part 154a as follows:

a. By revising the title to read as follows:

PART 154a—SPECIAL INTERIM REGULATIONS FOR ISSUANCE OF LETTERS OF COMPLIANCE TO BARGES AND EXISTING LIQUEFIED GAS VESSELS

b. By revising Paragraph 1 to read as follows:

1. *General.*

(a) *Applicability*—The regulations in this part apply to foreign flag vessels that—

(1) are barges that have onboard any of the products listed in Table 1 of Annex A to this part, as cargo, cargo residue, or vapor; or

(2) are self-propelled vessels that—

(i) have onboard any of the products listed in Table 4 of 46 CFR Part 154 as cargo, cargo residue, or vapor; and

(ii) are not regulated under Parts 153 or 154 of this chapter.

(b) *Purpose.*—This interim regulation prescribes procedures for the issuance of a Letter of Compliance to foreign flag barges and liquefied gas vessels carrying certain bulk dangerous cargoes which create potential unusual operating risks to life and property in U.S. ports. These unusual operating risks may be by virtue of the vessel design, the vessel operation or the cargoes carried.

A Letter of Compliance, valid for a period of not more than 2 years, is issued to vessels upon satisfactory completion of plan review and examination. Reissuance of a vessel's Letter of Compliance requires a satisfactory Coast Guard reexamination.

c. By striking the fifth paragraph of Paragraph 2.

d. By striking the words "for existing vessels," in the first sentence of Paragraph 4(a)(2)(i).

e. By striking Paragraph 4(a)(2)(ii).

f. By amending Paragraph 4 by revising (b)(1), (b)(3), (b)(5), (c), the first sentence of (d)(1)(iii), the last sentence of (e), (f)(1), (g)(2), and by deleting (h), to read as follows:

4. *Action.*

* * * * *

(b) * * *

(1) The required plans and specifications are reviewed using criteria equivalent to those used in the review of a similar design for U.S. registry. Review of self-propelled liquefied gas vessels is based upon those plans required in Annex A of this part and the requirements of Part 38 of this chapter. Review of barges is based upon the plans required in Annex A and the requirements of Part 151 of this chapter.

* * * * *

(3) Instead of initially submitting plans and drawings, the vessel's owner may submit the vessel's IMCO Certificate of Fitness issued by the flag administration under—

(i) the "IMCO Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk," adopted without amendments by Assembly Resolution A.328(IX);

(ii) the "IMCO Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk," adopted without amendments by Assembly Resolution A.329(IX) in accordance with IMCO Resolution A.329(IX);

(iii) the "IMCO Code for Existing Ships Carrying Liquefied Gases in Bulk." Following Coast Guard review of the IMCO Certificate of Fitness, the owner is advised of any additional plans and drawings needed for review.

* * * * *

(5) Upon completion of plan review, the Commandant (G–MHM) notifies the owner that plan review is complete and specifies the cargoes authorized for carriage and the applicable restrictions.

(c) *Notification of arrival*

After receiving notification from the Commandant (G–MHM) that plan review is complete, the owner may send his vessel to a U.S. port for examination. To arrange for the examination, the owner or charterer must notify the Commandant (G–MHM) in writing of the vessel's initial arrival, stating—

(1) the expected date of the vessel's arrival in U.S. waters;

(2) the port of call of the vessel;

(3) the vessel's agent in that port of call; and

(4) any cargoes the vessel is to carry.

This notification of arrival must be made at least 14 days before the vessel's date of arrival. Late notification may cause the vessel's examination and scheduled cargo operation to be delayed.

* * * * *

(d) * * *

(1) * * *

(iii) For those vessels that have an IMCO Certificate of Fitness, accepted by the Coast Guard under Paragraph 4(b)(3), a copy of the IMCO Certificate in English or French must be available for examination by the boarding party.* * *

* * * * *

(e) * * * For those vessels that have an IMCO Certificate of Fitness, accepted by the Coast Guard under Paragraph 4(b)(3), a copy of the certificate, in English or French, must be presented.

(f) * * *

(1) If the vessel meets all applicable requirements of these regulations, a Letter of Compliance is issued by the Coast Guard. The Letter of Compliance must be available for presentation to Coast Guard inspection parties whenever the vessel is boarded by Coast Guard personnel. The letter will indicate that the special cargo carrying and handling features of the vessel have been evaluated and found satisfactory for the cargoes specified. For subsequent vessel arrivals, the Captain of the Port, in conjunction with the Officer in Charge, Marine Inspection, will make such reexamination as he considers necessary to insure that the vessel has been maintained as initially examined. This will be in addition to the regular biennial reexamination. Vessels which have a Letter of Compliance issued on the basis of an IMCO Code certification must

maintain a valid certificate and provide the Commandant (G–MHM) with amendments to and updated copies of the certificate, whenever issued by the flag administration.

Changes of vessel name, vessel owner, vessel registry and modifications to the vessel's cargo containment system terminates the Letter of Compliance and must be reported to the Commandant (G–MHM). Upon completion of a satisfactory reexamination, a revised Letter of Compliance will be issued.

(g) * * *

(2) Cargo compatibility must be considered in preparing a loading diagram and in the subsequent cargo transfer operations. Proper safeguards against accidental mixing of reactive products would include consideration of such factors as avoidance of the use of common cargo and vent lines and carriage in adjacent tanks having a common bulkhead. The current compatibility guide entitled "Bulk Liquid Cargoes: Guide to Compatibility of Chemicals," should be consulted when determining the compatability of chemicals. A copy of the compatibility guide is enclosed with the Letter of Compliance when issued. Additional copies are available from the Commandant (G–MHM) upon request.

g. By amending Annex A, by deleting in Paragraph 2, the paragraph following the words "The Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402," and by deleting Table II and the note to Table II.

9. By adding a new Part 154 to read as follows:

PART 154—SAFETY STANDARDS FOR SELF-PROPELLED VESSELS CARRYING BULK LIQUEFIED GASES

Subpart A—General

Sec.
154.1 Applicability.
154.2 Carriage of liquefied gases in bulk.
154.3 Definitions and abbreviations.
154.4 U.S. flag vessel: endorsement application.
154.5 Foreign flag vessel: Letter of Compliance endorsement application.
154.6 U.S. flag vessel: Certificate of Inspection endorsement and IMCO Certificate.
154.8 Equivalents.
154.9 Special approval: requests.
154.10 Conflict in regulations.
154.12 Liquefied gases not included in Table 4.
154.13 Incorporation by reference.

Subpart B—Inspections and Tests

154.40—154.149 [Reserved]

Examination Requirements for a Letter of Compliance

154.150 Examination for a Letter of Compliance.
154.151 Scheduling a Letter of Compliance examination.
154.152 Notification of arrival for a Letter of Compliance examination.
154.153 Carrying a cargo into U.S. waters for a Letter of Compliance examination.

Subpart C—Design, Construction, and Equipment

Hull Structure

Sec.
154.170 Outer hull steel plating.
154.172 Contiguous steel hull structure.
154.174 Transverse contiguous hull structure.
154.176 Longitudinal contiguous hull structure.
154.178 Contiguous hull structure: heating system.
154.180 Contiguous hull structure: welding procedure.
154.182 Contiguous hull structure: production weld test.
154.188 Membrane tank: inner hull steel.
154.195 Aluminum tank: steel enclosure.

Ship Survival Capability and Cargo Tank Location

154.200 Stability requirements: general.
154.205 Intact stability requirements.
154.210 Damage stability requirement.
154.215 Hull type calculation.
154.220 Damage calculations.
154.225 Permeability of spaces and free surface effect.
154.230 Damage survival.
154.235 Cargo tank location.

Ship Arrangements

154.300 Segregation of hold spaces from other spaces.
154.305 Segregation of hold spaces from the sea.
154.310 Cargo piping systems.
154.315 Cargo pump and cargo compressor rooms.
154.320 Cargo control stations.
154.325 Accommodation, service, and control spaces.
154.330 Openings to accommodation, service, or control spaces.
154.340 Access to tanks and spaces in the cargo area.
154.345 Air locks.
154.350 Bilge and ballast systems in the cargo area.
154.355 Bow and stern loading piping.
154.356 Cargo emergency jettisoning piping.

Cargo Containment Systems

154.401 Definitions.
154.405 Design vapor pressure (P_o) of a cargo tank.
154.406 Design loads for cargo tanks and fixtures: general.
154.407 Cargo tank internal pressure head.
154.408 Cargo tank external pressure load.
154.409 Dynamic loads from vessel motion.
154.410 Cargo tank sloshing loads.
154.411 Cargo tank thermal loads.
154.412 Cargo tank corrosion allowance.

Integral Tanks

154.418 General.
154.419 Design vapor pressure.
154.420 Tank design.
154.421 Allowable stress.

Membrane Tanks

154.425 General.
154.426 Design vapor pressure.
154.427 Membrane tank system design.
154.428 Allowable stress.
154.429 Calculations.
154.430 Material test.
154.431 Model test.
154.432 Expansion and contraction.

Semi-Membrane Tanks

154.435 General.
154.436 Design vapor pressure.

Independent Tank Type A

154.437 General.
154.438 Design vapor pressure.
154.439 Tank design.
154.440 Allowable stress.

Independent Tank Type B

154.444 General.
154.445 Design vapor pressure.
154.446 Tank design.
154.447 Allowable stress.
154.448 Calculations.
154.449 Model test.

Independent Tank Type C and Process Pressure Vessels

154.450 General.
154.451 Design vapor pressure.
154.452 External pressure.
154.453 Failure to meet independent tank type C standards.

Secondary Barrier

154.459 General.
154.460 Design criteria.

Insulation

154.465 General.
154.466 Design criteria.
154.467 Submission of insulation information.

Support System

154.470 General.
154.471 Design criteria.
154.476 Cargo transfer devices and means.

Cargo and Process Piping Systems

154.500 Cargo and process piping standards.
154.503 Piping and piping system components: protection from movement.
154.506 Mechanical expansion joint: limits in a piping system.
154.512 Piping: thermal isolation.
154.514 Piping: electrical bonding.
154.516 Piping: hull protection.
154.517 Piping: liquid pressure relief.
154.519 Piping relief valves.
154.520 Piping calculations.
154.522 Materials for piping.
154.524 Piping joints: welded and screwed couplings.
154.526 Piping joints: flange connection.
154.528 Piping joints: flange type.
154.530 Valves: cargo tank MARVS 69 kPa gauge (10 psig) or lower.
154.532 Valves: cargo tank MARVS greater than 69 kPa gauge (10 psig).
154.534 Cargo pumps and cargo compressors.
154.536 Cargo tank gauging and measuring connections.
154.538 Cargo transfer connection.
154.540 Quick-closing shut-off valves: emergency shut-down system.
154.544 Quick-closing shut-off valves.
154.546 Excess flow valve: closing flow.

Sec.
154.548 Cargo piping: flow capacity.
154.550 Excess flow valve: bypass.
154.551 Cargo hose: general.
154.552 Cargo hose: compatibility.
154.554 Cargo hose: bursting pressure.
154.556 Cargo hose: maximum working pressure.
154.558 Cargo hose: marking.
154.560 Cargo hose: prototype test.
154.562 Cargo hose: hydrostatic test.

Materials

154.605 Toughness test.
154.610 Design temperature not colder than 0° C (32° F).
154.615 Design temperature below 0° C (32° F) and down to −55° C (−67° F).
154.620 Design temperature below −55° C (−67° F) and down to −165° C (−265° F).
154.625 Design temperature below 0° C (32° F) and down to −165° C (−265° F).
154.630 Cargo tank material.

Construction

154.650 Cargo tank and process pressure vessel welding.
154.655 Stress relief for independent tanks type C.
154.660 Pipe welding.
154.665 Welding procedures.

Cargo Pressure and Temperature Control

154.701 Cargo pressure and temperature control: general.
154.702 Refrigerated carriage.
154.703 Methane (LNG).
154.705 Cargo boil-off as fuel: general.
154.706 Cargo boil-off as fuel: fuel lines.
154.707 Cargo boil-off as fuel: ventilation.
154.708 Cargo boil-off as fuel: valves.
154.709 Cargo boil-off as fuel: gas detection equipment.

Cargo Vent Systems

154.801 Pressure relief systems.
154.802 Alternate pressure relief settings.
154.804 Vacuum protection.
154.806 Vent masts.
154.808 Capacity of pressure relief valves.

Atmospheric Control in Cargo Containment Systems

154.901 Atmospheric control within cargo tanks and cargo piping systems.
154.902 Atmospheric control within hold and interbarrier spaces.
154.903 Inert gas systems: general.
154.904 Inert gas system: controls.
154.906 Inert gas generators.
154.908 Inert gas generator: location.
154.910 Inert gas piping: location.
154.912 Inerted spaces: relief devices.

Electrical

154.1000 Applicability.
154.1002 Definition.
154.1005 Equipment approval.
154.1010 Electrical equipment in gas-dangerous space or zone.
154.1015 Lighting in gas-dangerous space.
154.1020 Emergency power.

Firefighting

Firefighting System: Exterior Water Spray

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154.1105 Exterior water spray system: general.
154.1110 Areas protected by system.
154.1115 Discharge.
154.1120 Nozzles.
154.1125 Pipes, fittings, and valves.
154.1130 Sections.
154.1135 Pumps.

Firefighting System: Dry Chemical

154.1140 Dry chemical system: general.
154.1145 Dry chemical supply.
154.1150 Distribution of dry chemical.
154.1155 Hand hose line: coverage.
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Cargo Area: Mechanical Ventilation System

154.1200 Mechanical ventilation system: general.
154.1205 Mechanical ventilations system: standards.
154.1210 Hold space, void space, cofferdam, and spaces containing cargo piping.

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154.1300 Liquid level gauging system: general.
154.1305 Liquid level gauging system: standards.
154.1310 Closed gauge shut-off valve.
154.1315 Restricted gauge excess flow valve.
154.1320 Sighting ports, tubular gauge glasses, and flat plate type gauge glasses.
154.1325 Liquid level alarm system: all cargo tanks.
154.1330 Liquid level alarm system: independent tank type C.
154.1335 Pressure and vacuum protection.
154.1340 Temperature measuring devices.
154.1345 Gas detection.
154.1350 Flammable gas detection system.
154.1360 Oxygen analyzer.
154.1365 Audible and visual alarms.
154.1370 Pressure gauge and vacuum gauge marking.
154.1375 Readout for temperature measuring device: marking.

Safety Equipment

154.1400 Safety equipment: all vessels.
154.1405 Respiratory protection.
154.1410 Decontamination shower.
154.1415 Air compressor.
154.1420 Stretchers and equipment.
154.1430 Equipment locker.
154.1435 Medical first aid guide.
154.1440 Antidotes.
154.1445 Lifesaving devices.

Subpart D—Special Design and Operating Requirements

154.1700 Materials of construction.
154.1705 Independent tank type C.
154.1710 Exclusion of air from cargo tank vapor spaces.
154.1715 Moisture control.
154.1720 Indirect refrigeration.
154.1725 Ethylene oxide.
154.1730 Ethylene oxide: loading and off-loading.

Sec.
154.1735 Methyl acetylene-propadiene mixture.
154.1740 Vinyl chloride: inhibiting and inerting.
154.1745 Vinyl chloride: transferring operations.
154.1750 Butadiene or vinyl chloride: refrigeration system.
154.1755 Nitrogen.
154.1760 Liquid ammonia.

Subpart E—Operations

154.1800 Special operating requirements under Part 35 of this chapter.
154.1801 Certificates, letters, and endorsements: U.S. flag vessels.
154.1802 Certificates, letters, and endorsements: foreign flag vessels.
154.1803 Expiration of Letters of Compliance.
154.1804 Document posted in wheelhouse.
154.1806 Regulations on board.
154.1808 Limitations in the endorsement.
154.1809 Loading and stability manual.
154.1810 Cargo manual.
154.1812 Operational information for terminal personnel.
154.1814 Cargo information cards.
154.1816 Cargo location plan.
154.1818 Certification of inhibition.
154.1820 Shipping document.
154.1822 Shipping document: copy for transfer terminal.
154.1824 Obstruction of pumproom ladderways.
154.1826 Opening of cargo tanks and cargo sampling.
154.1828 Spaces containing cargo vapor: entry.
154.1830 Warning sign.
154.1832 Incompatible cargo.
154.1834 Cargo transfer piping.
154.1836 Vapor venting as a means of cargo tank pressure and temperature control.
154.1838 Discharge by gas pressurization.
154.1840 Protective clothing.
154.1842 Cargo system: controls and alarms.
154.1844 Cargo tanks: filling limits.
154.1846 Relief valves: changing set pressure.
154.1848 Inerting.
154.1850 Entering cargo handling spaces.
154.1852 Air breathing equipment.
154.1854 Methane (LNG) as fuel.
154.1858 Cargo hose.
154.1860 Integral tanks: cargo colder than −10° C (14° F).
154.1862 Posting of speed reduction.
154.1864 Vessel speed within speed reduction.
154.1866 Cargo hose connection: transferring cargo.
154.1868 Portable blowers in personnel access openings.
154.1870 Bow and stern loading.
154.1872 Cargo emergency jettisoning.
Appendix A—Equivalent Stress.
Appendix B—Stress analyses definitions.

Authority: 92 Stat. 1480 (Port and Tanker Safety Act of 1978, 46 U.S.C. 391a); 49 CFR 1.46(n)(4).

PART 154—SAFETY STANDARDS FOR SELF-PROPELLED VESSELS CARRYING BULK LIQUEFIED GASES

Subpart A—General

§ 154.1 Applicability.

This part applies to each self-propelled vessel that has onboard bulk liquefied gases as a cargo, cargo residue, or vapor and that—

(a) Is constructed under a building contract awarded after October 31, 1976;

(b) In the absence of a building contract, has the keel laid or is at a similar stage of construction after December 31, 1976;

(c) Is delivered after June 30, 1980; or

(d) Has undergone a major conversion for which—

(1) The building contract is awarded after October 31, 1976;

(2) In the absence of a building contract, conversion is begun after December 31, 1976; or

(3) Conversion is completed after June 30, 1980.

§ 154.2 Carriage of liquefied gases in bulk.

Each vessel under this part must meet the design, construction and operating requirements of this part for carriage in bulk of a liquefied gas listed in Table 4.

§ 154.3 Definitions and abbreviations.

As used in this part:

"'A' Class Division" means a division as defined in Regulation 3 of Chapter II–2 of the 1974 Safety Convention.

"Accommodation spaces" means public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, pantries containing no cooking appliances and similar spaces. Public spaces are those portions of the accommodations that are used as halls, dining rooms, lounges and similar permanently enclosed spaces.

"Boiling point" means the temperature at which a cargo exhibits a vapor pressure equal to the atmospheric barometric pressure.

"Breadth (B)" means the maximum width of the vessel in meters measured amidships to the moulded line of the frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material.

"Cargo area" means that part of the vessel that contains the cargo containment system, cargo pump rooms, and cargo compressor rooms and includes the deck areas over the full beam and length of the vessel above them. The cargo area does not include the cofferdams, ballast spaces or void spaces at the after end of the aftermost hold space or the forward end of the forwardmost hold space.

"Cargo containment system" means the arrangement for containment of cargo including a primary and secondary barrier, associated insulation and any intervening spaces, and adjacent structure if necessary for the support of these elements.

"Cargo service space" means a space within the cargo area used for work shops, lockers, and store rooms of more than 2m² (21.5 ft.²) in area.

"Cargo tank" means the liquid tight shell that is the primary container of the cargo.

"Cofferdam" means the isolating space between two adjacent steel bulkheads or decks which in some cases are void spaces or ballast spaces.

"Contiguous hull structure" means hull structure that includes the inner deck, the inner bottom plating, longitudinal bulkhead plating, transverse bulkhead plating, floors, webs, stringers, and attached stiffeners.

"Control space" means those spaces in which the vessel's radio or main navigating equipment or the emergency source of power is located or where the fire control equipment, other than firefighting equipment required or permitted in the cargo area by §§ 154.1140 to 154.1170, is centralized.

"Design temperature" means the minimum temperature at which cargo is approved for loading, unloading or carriage.

"Design vapor pressure (P_o)" means the maximum gauge pressure at the top of the cargo tank for the design of the cargo tank.

"Flammable cargoes" means the following liquefied gases from Table 4:

Acetaldehyde
Butadiene
Butane
Butylene
Dimethylamine
Ethane
Ethylamine
Ethyl chloride
Ethylene
Ethylene oxide
Methane (LNG)
Methyl acetylene-propadiene mixture
Methyl bromide
Methyl chloride
Propane
Propylene
Vinyl chloride

"Flammable range" means the range between the minimum and maximum concentrations of vapor in air which form a flammable mixture.

"Gas-dangerous space" means:

(1) A space in the cargo area that does not have approved arrangements to ensure that its atmosphere is at all times maintained in a safe condition.

(2) An enclosed space outside the cargo area through which any piping that may contain liquid or gaseous cargo passes, or within which such piping terminates, unless it has approved arrangements that prevent any escape of gas into the atmosphere of this space.

(3) A cargo containment system and cargo piping.

(4) A hold space where cargo is carried in a cargo containment system required by this part to have a secondary barrier.

(5) A hold space where cargo is carried in a cargo containment system not required by this part to have a secondary barrier.

(6) A space separated from the hold space defined in subparagraph (4) of this definition by a single gastight boundary.

(7) A cargo pumproom and a cargo compressor room.

(8) A zone on the weather deck, or semi-enclosed space on the weather deck, within 3.05m (10 ft.) of any cargo tank outlet, gas or vapor outlet, cargo pipe flange, cargo valve, or of entrances and ventilation openings to a cargo pump room and cargo compressor room.

(9) The weather deck over the cargo area and 3.05m (10 ft.) forward and aft of the cargo area on the weather deck up to a height of 2.4m (8 ft.) above the weather deck.

(10) A zone within 2.4m (8 ft.) of the outer surface of a cargo containment system where the surface is exposed to the weather.

(11) An enclosed or semi-enclosed space in which there are lines containing cargo, except—

(i) A space with gas sampling lines going to gas detection equipment under § 154.1350(n); or

(ii) A space in which boil-off gas is used as fuel and complies with § 154.705.

(12) A space for storage of cargo hoses.

(13) An enclosed or semi-enclosed space having a direct opening into any gas-dangerous space or zone, as defined in subparagraphs (1) through (12) of this definition.

"Gas-safe space" means a space that is not a gas-dangerous space.

"Hold space" means the space enclosed by the vessel's structure in which there is a cargo containment system.

"IMCO" means the Inter-Governmental Maritime Consultative Organization.

"IMCO Certificate" means a Certificate of Fitness for the Carriage of Liquefied Gases in Bulk issued under the

IMCO *Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk*, adopted without amendments on November 12, 1975 by Assembly Resolution A. 328(IX).

"Independent tank" means a cargo tank that is permanently affixed to the vessel, is self-supporting, forms no part of the vessel's hull and is not essential to the strength or integrity of the hull.

"Independent tank type A" means an independent cargo tank designed primarily using classification society classical ship structural analysis procedures.

"Independent tank type B" means an independent cargo tank designed from model tests, refined analytical tools and analysis methods to determine stress levels, fatigue life and crack propagation characteristics.

"Independent tank type C" (pressure tank) means an independent cargo tank meeting pressure vessel criteria where the dominant stress producing load is design vapor pressure.

"Insulation space" means a space, that may or may not be an interbarrier space, occupied wholly or in part by insulation.

"Integral tank" means a cargo tank that forms a structural part of the vessel's hull and is influenced in the same manner and by the same loads that stress the adjacent hull structure.

"Interbarrier space" means the space between a primary and a secondary barrier, whether or not completely or partially occupied by insulation or other material.

"Length (L)" means ninety-six percent of the total length in meters on a waterline at eighty-five percent of the least molded depth measured from the top of the keel, or the length from the foreside of the stem to the axis of the rudder stock on that waterline, whichever is greater. In vessels designed with a rake of keel, the waterline on which L is measured is parallel to the design waterline.

"Letter of Compliance" means a letter issued by the Coast Guard that allows a foreign flag vessel to carry a bulk cargo regulated under this part.

"Liquefied gas" means a cargo having a vapor pressure of 172 kPa gauge (25 psia) or more at 37.8°C (100°F).

"MARVS" means the Maximum Allowable Relief Value Setting of a cargo tank.

"Membrane tank" means a cargo tank that is nonself-supporting and consists of a thin layer (membrane) supported through insulation by the adjacent hull structure.

"Permeability of a space" means the ratio of the volume within a space that is assumed to be occupied by water to the total volume of the space.

"Primary barrier" means the inner boundary that contains the cargo when the cargo containment system includes two boundaries.

"Process pressure vessel" means a pressure vesses that is used in a reliquefaction, cargo heating, or other system that processes cargo on board.

"Remote group alarm" means an audible and visual alarm which identifies that an alarm condition exists while not identifying the space in which the condition exists, nor the exact nature of the alarm.

"Secondary barrier" means the liquid resisting outer boundary of a cargo containment system when the cargo containment system includes two boundaries.

"Semi-membrane tank" means a cargo tank that is nonself-supporting in the loaded condition and consists of flat surfaces supported through insulation by the adjacent hull structure, and of shaped corners that connect the flat surfaces that can expand and contract due to thermal, hydrostatic, and pressure loading.

"Service space" means a space outside the cargo area used for a galley, pantry containing cooking appliances, locker or store room, workshop other than those forming part of the machinery spaces, and similar spaces and trunks to such spaces.

"Shut-off valve" means a valve that fully closes a pipeline and provides nominal metal to metal contact between the valve operating parts, including the disc and gate, and the valve body.

"Specific gravity (p)" means the ratio of the density of the cargo, at the lowest temperature at which it may be carried, to the density of water at 4°C (39°F).

"Tank cover" means the protective structure intended to protect the cargo containment system against damage where it protrudes through the weather deck, and to ensure the continuity and integrity of the deck structure.

"Tank dome" means the upward extension of a portion of the cargo tank. For below deck cargo containment systems, it means the extension of the cargo tank that protrudes through the weather deck or through a tank cover.

"Toxic cargoes" means the following liquefied gases from Table 4:

Acetaldehyde
Ammonia, anhydrous
Dimethylamine
Ethylamine
Ethyl chloride
Ethylene oxide
Methyl bromide
Methyl cloride
Sulfur dioxide
Vinyl chloride

"Vapor density" means the relative weight of the vapor compared with the weight of an equal volume of dry air at standard conditions of temperature and pressure.

"Vapor pressure" means the absolute equilibrium pressure of the saturated vapor above the liquid, expressed in kPa (psia), at a specific temperature.

"Void space" means an enclosed space in the cargo area external to a cargo containment system, other than a hold space, ballast space, fuel oil tank, cargo pump or compressor room, or any space used by personnel.

"1974 Safety Convention" means the International Convention on Safety of Life at Sea, 1974, done at London, November 1, 1974.

§ 154.4 U.S. flag vessel: Endorsement application.

(a) A person who desires the endorsement required by § 154.1801 for a U.S. flag vessel must submit an application to an Officer in Charge, Marine Inspection, in the inspection zone in which the vessel is to be built, for an endorsement of the vessel's subchapter D Certificate of Inspection.

(b) The person requesting an endorsement under paragraph (a) of this section must submit to the Coast Guard when requested—

(1) Hull type calculation required by § 154.215;

(2) The plans and information listed in §§ 54.01–18, 56.01–10, 91.55–5 (a), (b), (d), (g), and (h), and 111.05–5(d) of this chapter;

(3) Plans for the dry chemical supply and distribution systems, including the controls; and

(4) Any other vessel information, such as plans, design calculation, test results, certificates, and manufacturer's data, that the Coast Guard needs to determine whether or not the vessel meets the standards of this part.

§ 154.5 Foreign flag vessel: Letter of Compliance endorsement application.

(a) A person who desires an endorsed Letter of Compliance required under § 154.1802(a) for a foreign flag vessel, whose flag administration issues IMCO Certificates, must submit to the Commandant (G–MHM), U.S. Coast Guard, Washington, D.C., 20590, a copy of the IMCO Certificate [1] issued to the vessel with—

(1) The design ambient temperatures and cargo tank design stress factors,

[1] Usually, the IMCO Certificate is sufficient for the Coast Guard to endorse the vessel's Letter of Compliance with the names of those cargoes in Table 4 that are listed on the IMCO Certificate.

listed in item 3 of the IMCO Certificate, that meet §§ 154.174, 154.176, 154.215(c), 154.447, 154.450 and 154.466;

(2) A classification society certification that the vessel complies with the requirements of § 154.170 and §§ 154.701 through 154.709;

(3) A description of the vessel;

(4) Specifications for the cargo containment system;

(5) A general arrangement plan of the vessel;

(6) A midship section plan of the vessel;

(7) Schematic plans of the liquid and vapor cargo piping;

(8) A firefighting and safety plan;

(9) The vessel's Cargo Ship Safety Construction Certificate and Cargo Ship Safety Equipment Certificate issued under the International Convention for Safety of Life at Sea, 1960; and

(10) Any additional plans, certificates, and information that the Commandant (G–MHM) may request.

(b) A person who desires an endorsed Letter of Compliance required under § 154.1802(b) for a foreign flag vessel, whose flag administration does not issue IMCO Certificates, must submit to the Commandant (G–MHM) the plans, calculations, and information under § 154.4(b).

(c) Correspondence to the Coast Guard and vessel information submitted under this part must be in English, except—

(i) IMCO Certificates may be in French; and

(ii) SOLAS Certificates may be in the official language of the flag administration.

§ 154.6 U.S. flag vessel: Certificate of inspection endorsement and IMCO Certificate.

The Certificate of Inspection for a U.S. flag vessel intended to carry any liquefied gas is endorsed for each individual cargo as follows:

"Inspected and approved for the carriage of (enter the applicable cargo name) at a maximum allowable relief valve setting of ———— kPa gauge (———— psig) with an F factor of ————, a maximum external pressure of ———— kPa gauge (———— psig), a minimum service temperature of ———— °C (———— °F), and a maximum specific gravity of ————. Hull type ————."

(b) The Coast Guard also issues an IMCO Certificate if requested by the U.S. flag vessel's owner or operator.

§ 154.8 Equivalents.

(a) Where a vessel must have particular fitting, material, appliance, apparatus, equipment, provision, procedure, or arrangement, including cargo segregation, the Commandant may accept any other fitting, material, appliance, appartus, equipment, provision, procedure, or arrangement, that he determines to be as effective as that specified in this part.

(b) In any case where it is shown to the satisfaction of the Commandant that the use of any particular equipment, apparatus, or arrangement not specifically required by statute, but prescribed by regulations is unreasonable or impracticable, the Commandant may allow the use of alternate equipment, apparatus, or arrangement to such an extent and upon such conditions as will insure a degree of safety consistent with the minimum standards set forth in this part.

(c) Operational methods or procedures are generally not substituted for a particular fitting, material, appliance, apparatus, item or type of equipment, required in this part.

§ 154.9 Special approval: requests.

Each request for special approval must be in writing to the Commandant (G–MHM) or (G–MMT) as required under this part. The mailing address is as follows:

Commandant (G–MHM) or Commandant (G–MMT), U.S. Coast Guard, Washington, D.C. 20590.

§ 154.10 Conflict in regulations.

(a) When a specific requirement in another part of this chapter is in conflict with any requirement in this part, the regulations in this part take precedence.

(b) When a vessel carries cargoes regulated by this part and by another part, the requirements of both parts must be met.

§ 154.12 Liquefied gases not included in Table 4.

(a) A liquefied gas not appearing in Table 4 must be specially approved by the Commandant (G–MHM) for carriage in bulk in U.S. waters.

(b) A person who desires to ship a liquefied gas in bulk that is not listed in Table 4, must submit to the Commandant (G–MHM) a completed form CG–4355. This form may be obtained from either Commandant (G–MHM) or any Officer in Charge, Marine Inspection (OCMI), at the nearest port.

§ 154.13 Incorporation by reference.

Industry standards referred to in this part were approved under 1 CFR Part 151 for incorporation by reference in this chapter by the director of the Federal Register on November 21, 1967. These industry standards are on file in the Federal Register library and are available from the appropriate organization at the following addresses:

(a) American Bureau of Shipping, 65 Broadway, New York, New York 10006.

(b) American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.

(c) American National Standards Institute, 1430 Broadway, New York, New York 10018.

Subpart B—Inspections and Tests

§ 154.40–§ 154.140 (Reserved)

Examination Requirements for a Letter of Compliance

§ 154.150 Examination for a Letter of Compliance.

Before a Letter of Compliance is issued by the Coast Guard to a foreign flag vessel, the vessel's owner must have his vessel examined by the Coast Guard in a U.S. port to determine whether or not it meets the requirements of this part.

§ 154.151 Scheduling a Letter of Compliance examination.

The Commandant (G–MHM) schedules the Letter of Compliance examination under § 154.150 after—

(a) The Coast Guard has completed review of the vessel's plans or has accepted the vessel's IMCO Certificate; and

(b) Receiving a written request for examination from the owner with—

(1) The expected date of the vessel's arrival in U.S. waters;

(2) The port of call where the vessel is to be inspected;

(3) The vessel's agent in the port of call; and

(4) Any cargoes the vessel is to carry under § 154.153.

§ 154.152 Notification of arrival for a Letter of Compliance examination.

A Letter of Compliance examination is scheduled 14 days or more after the request under § 154.151(b) has been received, unless the Commandant (G–MHM) concurs in a request to arrange for an examination in less than 14 days after the request is received.

§ 154.153 Carrying a cargo into U.S. waters for a Letter of Compliance examination.

When entering U.S. waters for an examination under §§ 154.150 and 154.151, a vessel that has not been issued a Letter of Compliance or whose Letter of Compliance has expired or been revoked may not carry cargo regulated under this part unless that

carriage is specially approved by the Commandant (G–MHM).

Subpart C—Design, Construction and Equipment

Hull Structure

§ 154.170 Outer hull steel plating.

(a) Except as required in paragraph (b) of this section, the outer hull steel plating, including the shell and deck plating must meet the material standards of the American Bureau of Shipping published in "Rules for Building and Classing Steel Vessels" 1976.

(b) Along the length of the cargo area, grades of steel must be as follows:

(1) The deck stringer and sheer strake must be at least Grade E steel or a grade of steel that has equivalent chemical properties, mechanical properties, and heat treatment, and that is specially approved by the Commandant (G–MMT).

(2) The strake at the turn of the bilge must be Grade D, Grade E, or a grade of steel that has equivalent chemical properties, mechanical properties, and heat treatment, and that is specially approved by the Commandant (G–MMT).

(3) The outer hull steel vessels must meet the standards in § 154.172 if the hull steel temperature is calculated to be below −5° C (23° F) assuming—

(i) For any waters in the world, the ambient cold conditions of still air at 5° C (41° F) and still sea water at 0° C (32° F);

(ii) For cargo containment systems with secondary barriers, the temperature of the secondary barrier is the design temperature; and

(iii) For cargo containment systems without secondary barriers, the temperature of the cargo tank is the design temperature.

§ 154.172 Contiguous steel hull structure.

(a) Except as allowed in paragraphs (b) and (c) of this section, plates, forgings, forged and rolled fittings, and rolled and forged bars and shapes used in the construction of the contiguous steel hull structure must meet the thickness and steel grade in Table 1 for the temperatures under § 154.174(b) and 154.176(b).

(b) for a minimum temperature, determined under §§ 154.174(b) and 154.176(b), below −25° C (13° F), the contiguous steel hull structure must meet § 54.25–10 for that minimum temperature.

(c) If a steel grade that is not listed in Table 1 has the equivalent chemical properties, mechanical properties, and heat treatment of a steel grade that is listed, the steel grade not listed may be specially approved by the Commandant (G–MMT), for use in the contiguous hull structure.

Table 1.—Minimum Temperature, Thickness, and Steel Grades in Contiguous Hull Structures.

Minimum temperature	Steel thickness	Steel[1] grade
0° C (32° F)	All	Standards of the American Bureau of Shipping published in "Rules for Building and Classing Steel Vessels", 1976
−10° C (14° F)	t≤12.5mm (½ in.)	B
	12.5<t≤25.5mm(1 in.)	D
	t>25.5mm(1 in.)	E
−25° C (−13° F)	t≤12.5mm ½ in.)	D
	t>12.5mm (½ in.)	E

[1] Steel grade of the American Bureau of Shipping published in "Rules for Building and Classing Steel Vessels", 1976.

§ 154.174 Transverse contiguous hull structure.

(a) The transverse contiguous hull structure of a vessel having cargo containment systems without secondary barriers must meet the standards of the American Bureau of Shipping published in "Rules for Building and Classing Steel Vessels", 1976.

(b) The transverse contiguous hull structure of a vessel having cargo containment systems with secondary barriers must be designed for a temperature that is—

(1) Colder than the calculated temperature of this hull structure when—

(i) The temperature of the secondary barrier is the design temperature, and

(ii) The ambient cold condition under § 154.176(b)(1)(ii) and (iii) are assumed; or

(2) Maintained by the heating system under § 154.178.

§ 154.176 Longitudinal contiguous hull structure.

(a) The longitudinal contiguous hull structure of a vessel having cargo containment systems without secondary barriers must meet the standards of the American Bureau of Shipping published in "Rules for Building and Classing Steel Vessels", 1976.

(b) the longitudinal contiguous hull structure of a vessel having cargo containment systems with secondary barriers must be designed for a temperature that is—

(1) Colder than the calculated temperature of this hull structure when—

(i) The temperature of the secondary barrier is the design temperature; and

(ii) For any waters in the world except Alaskan waters, the ambient cold condition of—

(A) Five knots air at −18° C (0° F); and

(B) Still sea water at 0° C (32° F); or

(iii) For Alaskan waters the ambient cold condition of—

(A) Five knots air at −29° C (−20° F); and

(B) Still sea water at −2° C (28° F); or

(2) Maintained by the heating system under § 154.178, if, without heat, the contiguous hull structure is designed for a temperature that is colder than the calculated temperature of the hull structure assuming the—

(i) Temperature of the secondary barrier is the design temperature; and

(ii) Ambient cold conditions of still air at 5° C (41° F) and still sea water at 0° C (32° F).

§ 154.178 Contiguous hull structure: heating system.

The heating system for transverse and longitudinal contiguous hull structure must—

(a) Be shown by a heat load calculation to have the heating capacity to meet § 154.174(b)(2) or § 154.176(b)(2);

(b) Have stand-by heating to provide 100% of the required heat load and distribution determined under paragraph (a); and

(c) Meet Parts 52, 53, and 54 of this chapter.

§ 154.180 Contiguous hull structure: welding procedure.

Welding procedure tests for contiguous hull structure designed for a temperature colder than −18° C (0° F) must meet § 54.05–15 and Subpart 57.06 of this chapter.

§ 154.182 Contiguous hull structure: production weld test.

If a portion of the contiguous hull structure is designed for a temperature colder than −34° C (−30° F) and is not part of the secondary barrier, each 100m (328 ft.) of full penetration butt welded joints in that portion of the contiguous hull structure must pass the following production weld tests in the position that the joint is welded:

(a) Bend tests under § 57.06–4 of this chapter.

(b) A Charpy V-notch toughness test under § 57.06–5 of this chapter on one set of 3 specimens alternating the notch location on successive tests between the

center of the weld and the most critical location in the heat affected zone.[1]

(c) If the contiguous hull structure does not pass the test under paragraph (b) of this section, the retest procedures under § 54.05–5(c) must be met.

§ 154.188 Membrane tank: inner hull steel.

For a vessel with membrane tanks, the inner hull plating thickness must meet the deep tank requirements of the American Bureau of Shipping published in "Rules for Building and Classing Steel Vessels", 1976.

§ 154.195 Aluminum cargo tank: steel enclosure.

(a) An aluminum cargo tank and its dome must be enclosed by the vessel's hull structure or a separate steel cover.

(b) The steel cover for the aluminum cargo tank must meet the steel structural standards of the American Bureau of Shipping published in "Rules for Building and Classing Steel Vessels", 1976.

(c) The steel cover for the aluminum tank dome must be—

(1) At least 3.2 mm (⅛ in.) thick;

(2) Separated from the tank dome, except at the support points; and

(3) Thermally isolated from the dome.

Ship Survival Capability and Cargo Tank Location

§ 154.200 Stability requirements: general.

Each vessel must be stable for the full range of operating drafts including the affects on stability of any empty or partially filled tanks and the weight and volume of cargoes carried.

§ 154.205 Intact stability requirements.

(a) Each vessel must meet Part 93 of this chapter.

(b) During loading and unloading, the vessel must have at least 50 mm (2 inches) of positive metacentric height which can be maintained by water ballast and the sequencing of cargo loading and unloading.

§ 154.210 Damage stability requirement.

(a) Each vessel must be shown by design calculations to meet the survival presumptions in § 154.230 assuming the damage for the cargo it carries in the hull type specified in § 154.215.

(b) For the carriage of a cargo listed in Table 4, the vessel must be at least the ship type specified in Table 4 for that cargo.

Note.—Products with the greatest hazard are carried in a Type IG hull. Products with lesser hazards are carried in Type IIG/IIPG or Type IIIG hulls.

§ 154.215 Hull type calculation.

(a) Where Table 4 requires a type IG hull, design calculations must show that the vessel can survive damage at any location.

(b) Where Table 4 requires a type IIG hull, design calculations must show that a vessel—

(1) Longer than 150 m (492 ft.) in length can survive damage at any location; and

(2) 150 m (492 ft.) or less in length can survive damage at any location except the transverse bulkheads bounding an aft machinery space.

(c) If a vessel has independent tanks type C with a MARVS of 689 kPa gauge (100 psig), is 150 m (492 ft.) or less in length, and Table 4 allows a type II PG hull, the design calculations must show that the vessel can survive damage at any location, except on transverse bulkheads spaced farther apart than the longitudinal extent of damage specified in § 154.220(b)(1)(i).

(d) Where Table 4 requires a type IIIG hull, design calculations must show that a vessel—

(1) 125 m (410 ft.) or longer can survive damage at any location except on transverse bulkheads spaced farther apart than the longitudinal extent of damage specified in § 154.220(b)(1)(i); and

(2) Shorter than 125 m (410 ft.) can survive damage at any location, except on transverse bulkheads spaced farther apart than the longitudinal extent of damage specified in § 154.220(b)(1)(i) and except in the main machinery space.

(e) For the purposes of paragraphs (c) and (d) of this section, damage must be assumed to transverse bulkheads spaced closer than the longitudinal extent of damage specified in § 154.220(b)(1)(i), and a main transverse bulkhead or a transverse bulkhead bounding side tanks or double bottom tanks must be assumed damaged if there is a step or a recess in a transverse bulkhead that is longer than 3.05 m (10 ft.) located within the extent of penetration of assumed damage. The step formed by the after peak bulkhead and after peak tank top is not a step for the purpose of this regulation.

§ 154.220 Damage calculations.

(a) For the purpose of § 154.210, design calculations must include both side and bottom damage, applied separately.

(b) Damage must consist of the most disabling penetration up to and including penetrations having the following dimensions:

(1) For side penetrations—(i) A longitudinal extent of $1/3L^{2/3}$ or 14.5 m ($0.495L^{2/3}$ or 47.6 ft.), whichever is shorter;

(ii) A transverse extent (inboard from the ship's side at right angles to the centerline at the level of the summer load line assigned under Subchapter E of this chapter) of B/5 or 11.5 m (37.7 ft.), whichever is shorter; and

(iii) A vertical extent measuring from the base line upward without limits.

(2) For bottom penetrations—(i) At the forward end but not including any damage aft of a point 0.3L aft of the forward perpendicular—

(A) A longitudinal extent of $1/3L^{2/3}$ or 14.5 m ($0.495L^{2/3}$ or 47.6 ft.), whichever is shorter;

(B) A transverse extent of B/6 or 10 m (32.8 ft.), whichever is shorter; and

(C) A vertical extent, from the molded line of the shell at the centerline, of B/15 or 2 m (6.6 ft.), whichever is shorter; and

(ii) At any longitudinal position aft of a point 0.3L aft of the forward perpendicular—

(A) A longitudinal extent of L/10 or 5 m (16.4 ft.), whichever is shorter;

(B) A transverse extent of B/6 or 5 m (16.4 ft.), whichever is shorter; and

(C) A vertical extent, from the molded line of the shell at the centerline, of B/15 or 2 m (6.6 ft.), whichever is shorter.

(c) When the damage assumption excludes a transverse bulkhead bounding a machinery space, the machinery space must be assumed to be damaged as a case separate from the side and bottom penetration.

§ 154.225 Permeability of spaces and free surface effect.

(a) The free surface effect must be calculated at an angle of heel of 5° for each individual space or the effect of free liquid in a tank must be calculated by assessing the shift of liquids by moment of transference calculations.

(b) In calculating the effect of free surfaces of consumable liquids, it must be assumed that, for each type of liquid, at least one transverse pair of wing tanks or a single center line tank has a free surface. The tank or combination of tanks selected must be those where the effect of free surfaces is the greatest.

(c) Calculations in which a machinery space is treated as a floodable space must be based on an assumed machinery space permeability of 0.85, unless the use of an assumed permeability of less than 0.85 is justified in detail.

(d) The assumed permeability of a floodable space other than a machinery

[1] The most critical location in the heat affected zone of the weld is based on procedure qualification results, except austenitic stainless steel need have notches only in the center of the weld.

space must be as listed in the following table:

Space	Permeability
Storerooms	0.60.
Accommodation spaces.	0.95.
Void	0.95.
Consumable liquid tanks.	0.95 or 0, whichever results in the more disabling.
Other liquid tanks	0.95 or 0, the permeability of partially filled tanks must be consistent with the density and amount of liquid carried.

(e) Wherever damage penetrates a cargo tank it must be assumed that the cargo is completely lost from the compartment and replaced by salt water up to the level of the final plane of equilibrium.

§ 154.230 Damage survival.

A vessel is presumed to survive assumed damage if it meets the following conditions in the final stage of flooding:

(a) *Heel angle.* The maximum angle of heel must not exceed 30°.

(b) *Final waterline.* The waterline, taking into account sinkage, heel and trim, must be below the lower edge of openings such as air pipes and openings closed by weathertight doors or hatch covers, except openings closed by means of watertight manhole covers and watertight flush scuttles, small watertight cargo tank hatch covers that maintain the high integrity of the deck, remotely operated watertight sliding doors, and side scuttles of the non-opening type.

(c) *Range of stability.*—(1) The righting lever curve must be positive and have a minimum range of 20° beyond the angle of equilibrium.

(2) The maximum righting lever within the range specified in paragraph (c)(1) of this section must be at least 100 mm (4 in.).

(3) Each opening within the 20° range beyond the angle of equilibrium must be at least weathertight.

(d) *Metacentric height.*—After flooding the vessel's metacentric height must be at least 50 mm (2 inches) when the vessel is in the upright position.

(e) *Bouyancy of superstructure.*—The bouyancy of superstructures directly above the side damage is not included except that the unflooded parts of superstructures beyond the extent of that damage may be included if they are separated from the damaged space by watertight bulkheads and meet paragraph (b) of this section. Hinged watertight doors may be in watertight bulkheads in the superstructure if they meet Subpart 73.35 of this chapter.

(f) *Local damage.*—The maximum angle of heel must not exceed the greater of 30° or the angle at which restoration of propulsion, steering engine power, and use of the ballast system is precluded for local damage, extending 760 mm (30 in.) normal to the hull shell, that affects a—

(1) Longitudinal bulkhead; and

(2) Transverse bulkhead on type IG and IIG vessels.

(g) *Equalization arrangements.*—Equalization arrangements requiring mechanical aids such as valves or cross-flooding lines may not be considered for reducing the angle of heel. Spaces joined by ducts of large cross-sectional area are treated as common spaces.

(h) *Progressive flooding.*—If pipes, ducts, or tunnels are within the assumed extent of damage, arrangements must be made to prevent progressive flooding in a space that is not assumed to be flooded in the damaged stability calculations. If an intermediate stage of flooding is more critical than the final stage, calculations for the intermediate stage must be submitted for special approval by Commandant (G–MMT).

§ 154.235 Cargo tank location.

(a) For type IG hulls, cargo tanks must be located inboard of—

(1) The transverse damage specified in 154.220(b)(1)(ii);

(2) The vertical damage specified in §§ 154.220(b)(2)(i)(C) and 154.220(b)(2)(ii)(C); and

(3) 760 mm (30 inches) from the shell plating.

(b) For type IIG, IIPG, and IIIG hulls, cargo tanks must be located inboard of—

(1) The vertical extent of damage under §§ 154.220(b)(2)(i)(C) and 154.220(b)(2)(ii)(C); and

(2) 760 mm (30 inches) from the shell plating.

(c) In vessels having membrane and semi-membrane tanks, the vertical and transverse extents of damage must be measured to the inner hull.

(d) For type IIG, IIPG, and IIIG hulls, cargo tank suction wells may penetrate into the area of bottom damage specified in §§ 154.220(b)(2)(i)(C) and 154.220(b)(2)(ii)(C) if the penetration is the lesser of 25% of the double bottom height or 350 mm (13.8 in.).

Ship Arrangements

§ 154.300 Segregation of hold spaces from other spaces.

Hold spaces must be segregated from machinery and boiler spaces, accommodation, service and control spaces, chain lockers, potable, domestic and feed water tanks, store rooms and spaces immediately below or outboard of hold spaces by a—

(a) Cofferdam, fuel oil tank, or single gastight A–60 Class Division of all welded construction in a cargo containment system not required by this part to have a secondary barrier;

(b) Cofferdam or fuel oil tank in a cargo containment system required by this part to have a secondary barrier; or

(c) If there are no sources of ignition or fire hazards in the adjoining space, single gastight A–O Class Division of all welded construction.

§ 154.305 Segregation of hold spaces from the sea.

In vessels having cargo containment systems required by this part to have a secondary barrier, hold spaces must be segregated from the sea by—

(a) A double bottom if the cargo tanks meet this part for design temperatures colder than −10° C (14° F); and

(b) Wing tanks if the cargo tanks meet this part for design temperatures colder than −55° C (−67° F).

§ 154.310 Cargo piping systems.

Cargo liquid or vapor piping must—

(a) Be separated from other piping systems, except where an interconnection to inert gas or purge piping is required by § 154.901(a);

(b) Not enter or pass through any accommodation, service, or control space;

(c) Except as allowed under § 154.703, not enter or pass through a machinery space other than a cargo pump or compressor room;

(d) Be in the cargo area except—

(1) As allowed under § 154.703;

(2) Bow and stern loading piping; and

(3) Emergency jettisoning piping.

(e) Be above the weather deck except—

(1) As allowed under § 154.703;

(2) Pipes in a trunk traversing void spaces above a cargo containment system; and

(3) Pipes for draining, venting, or purging interbarrier and hold spaces;

(f) Connect into the cargo containment system above the weather deck except—

(1) Pipes in a trunk traversing void spaces above a cargo containment system; and

(2) Pipes for draining, venting, or purging interbarrier and hold spaces.

(g) Be inboard of the transverse cargo tank location required by § 154.235, except for athwartship shore connection manifolds not subject to internal pressure at sea.

§ 154.315 Cargo pump and cargo compressor rooms.

(a) Cargo pump rooms and cargo compressor rooms must be above the weather deck and must be within the cargo area.

(b) Where pumps and compressors are driven by a prime mover in an adjacent gas safe space—

(1) The bulkhead or deck must be gastight; and

(2) The shafting passing through the bulkhead or deck must be sealed by a fixed oil reservoir gland seal, a pressure grease seal, or another type of positive pressure seal specially approved by the Commandant (G–MMT).

§ 154.320 Cargo control stations.

(a) Cargo control stations must be above the weather deck.

(b) If a cargo control station is in accommodation, service, or control spaces or has access to such a space, the station must—

(1) Be a gas safe space;

(2) Have an access to the space that meets § 154.330; and

(3) Have indirect reading instrumentation, except for gas detectors.

(c) Cargo control stations, including a room or area, must contain all alarms, indicators, and remote controls associated with each cargo tank that the station controls.

§ 154.325 Accommodation, service, and control spaces.

(a) Accommodation, service, and control spaces must be outside the cargo area.

(b) If a hold space having a cargo containment system, required by this part to have a secondary barrier, is separated from any accommodation, service, or control space by a cruciform joint, there must be a cofferdam providing at least 760 mm (30 inches) by 760 mm (30 inches) clearance on one side of the cruciform joint.

§ 154.330 Openings to accommodation, service, or control spaces.

(a) Entrances, forced or natural ventilation intakes and exhausts, and other openings to accommodation, service, or control spaces, except as allowed in paragraph (c) of this section, must be—

(1) At least L/25 or 3.05m (10 ft) from the athwartship bulkhead facing the cargo area, whichever is farther, except that the distance need not exceed 5m (16.4 ft); and

(2) On a house athwartship bulkhead not facing the cargo area or on the outboard side of the house.

(b) Each port light, located on the athwartship bulkhead of a house facing the cargo area or the house sides within the distance specified in paragraph (a)(1) of this section, must be a fixed type.

(c) Wheelhouse doors and windows that are not fixed may be within the distance specified in paragraph (a)(1) of this section from the athwartship bulkhead of a house facing the cargo area, if they have gaskets and pass a tightness test with a fire hose at not less than 207 kPa gauge (30 psig).

(d) Port lights in the hull plating below the uppermost continuous deck and in the first tier of the superstructure must be a fixed type.

(e) Air intakes and openings into accommodation, service, and control spaces must have metal closures that pass a tightness test with a fire hose at not less than 207 kPa gauge (30 psig).

(f) On liquefied toxic gas vessels, the closures required in paragraph (e) of this section must be capable of being closed from inside the space.

§ 154.340 Access to tanks and spaces in the cargo area.

(a) Each cargo tank must have a manhole from the weather deck, the clear opening of which is at least 600 mm by 600 mm (23.6 in. by 23.6 in.).

(b) Each access into and through a void space or other gas-dangerous space in the cargo area, except spaces under subparagraph (6) of the definition for "gas-dangerous space" in § 154.3, must—

(1) Have a clear opening of at least 600 mm by 600 mm (23.6 in. by 23.6 in.) through horizontal openings, hatches, or manholes;

(2) Have a clear opening of at least 600 mm by 800 mm (23.6 in. by 31.5 in.) through bulkheads, frames or other vertical structural members; and

(3) Have a fixed ladder if the lower edge of a vertical opening is more than 600 mm (23.6 in.) above the deck or bottom plating.

(c) Each access trunk in the cargo area must be at least 760 mm (30 in.) in diameter.

(d) The lower edge of each access from the weather deck to gas-safe spaces in the cargo area must be at least 2.4 m (7.9 ft.) above the weather deck or the access must be through an air lock that meets § 154.345.

(e) The inner hull in the cargo area must be accessible for inspection from at least one side without the removal of any fixed structure or fitting.

(f) The hold space insulation in the cargo area must be accessible for inspection from at least one side from within the hold space or there must be a means, that is specially approved by the Commandant, of determining from outside the hold space whether or not the hold space insulation meets this part.

§ 154.345 Air locks.

(a) An air lock may be used for access from a gas-dangerous zone on the weather deck to a gas-safe space.

(b) Each air lock must—

(1) Consist of two steel doors, at least 1.5 m (4.9 ft.) but not more than 2.5 m (8.2 ft.) apart, each gasketed and tight when tested with a fire hose at not less 207 kPa gauge (30 psig);

(2) Have self-closing doors with no latches or other devices for holding them open;

(3) Have an audible and visual alarm on both sides which are actuated when both door securing devices are in other than the fully closed position at the same time;

(4) Have mechanical ventilation in the space between the doors from a gas-safe area;

(5) Have a pressure greater than that of the gas-dangerous area on the weather deck;

(6) Have the rate of air change in the space between the doors of at least 8 changes per hour; and

(7) Have the space between the doors monitored for cargo vapor leaks under § 154.1350.

(c) In addition to the requirements of paragraphs (a) and (b) of this section, no gas-safe space on a liquefied flammable gas carrier may have an air lock unless the space—

(1) Is mechanically ventilated to make the pressure in the space greater than that in the air lock; and

(2) Has a means of automatically de-energizing all electrical equipment that is not explosion-proof in the space when the pressure in the space falls to or below the pressure in the air lock.

§ 154.350 Bilge and ballast systems in the cargo area.

(a) Hold, interbarrier, and insulation spaces must have a means of sounding the space or other means of detecting liquid leakage specially approved by the Commandant (G–MMT).

(b) Each hold and insulation space must have a bilge drainage system.

(c) Interbarrier spaces must have an eductor or pump for removing liquid cargo and returning it to the cargo tanks or to an emergency jettisoning system meeting § 154.356.

(d) Spaces in the cargo containment portion of the vessel, except ballast spaces and gas-safe spaces, must not

connect to pumps in the main machinery space.

§ 154.355 Bow and stern loading piping.

(a) Bow and stern loading piping must—

(1) Meet § 154.310;

(2) Be installed in an area away from the accommodation, service, or control space on type IG hulls;

(3) Be clearly marked;

(4) Be segregated from the cargo piping by a removable spool piece in the cargo area or by at least two shut-off valves in the cargo area that have means of locking to meet § 154.1870(a);

(5) Have a means for checking for cargo vapor between the two valves under paragraph (a)(4) of this section;

(6) Have fixed inert gas purging lines; and

(7) Have fixed vent lines for purging with inert gas to meet § 154.1870(b).

(b) Entrances, forced or natural ventilation intakes, exhausts, and other openings to accommodation, service, or control spaces that face the bow or stern loading area must meet § 154.330.

§ 154.356 Cargo emergency jettisoning piping.

Emergency jettisoning piping must—

(a) Meet § 154.355(a);

(b) Be designed to allow cargo discharge without the outer hull steel temperature falling below the minimum temperatures under §§ 154.170 and 154.172; and

(c) Be specially approved by the Commandant (G–MMT).

Cargo Containment Systems

§ 154.401 Definitions.

As used in §§154.440 and 154.447:

"σ_Y" means the minimum yield strength of the tank material, including weld metal, at room temperature.

"σ_B" means minimum tensile strength of the tank material, including weld metals, at room temperature.

§ 154.405 Design vapor pressure (P_o) of a cargo tank.

(a) The design vapor pressure (P_o) of a cargo tank must be equal to or greater than the MARVS.

(b) The P_o of a cargo tank must be equal to or greater than the vapor pressure of the cargo at 45° C (113° F) if—

(1) The cargo tank has no temperature control for the cargo; and

(2) The vapor pressure of the cargo results solely from ambient temperature.

(c) The P_o of a cargo tank may be exceeded under harbor conditions if specially approved by the Commandant (G–MMT).

§ 154.406 Design loads for cargo tanks and fixtures; general.

(a) Calculations must show that a cargo tank and its fixtures are designed for the following loads:

(1) Internal pressure head.

(2) External pressure load.

(3) Dynamic loads resulting from the motion of the vessel.

(4) Transient or stationary thermal loads if the design temperature is colder that −55° C (−67° F) or causes thermal stresses in cargo tank supports.

(5) Sloshing loads, if the cargo tank is designed for partial loads.

(6) Loads resulting from vessel's deflection.

(7) Tank weight, cargo weight, and corresponding support reaction.

(8) Insulation weight.

(9) Loads of a pipe tower and any other attachments to the cargo tank.

(10) Vapor pressure loads in harbor conditions allowed under § 154.405.

(11) Gas pressurization if the cargo tank is designed for gas pressurization as a means of cargo transfer.

(b) A cargo tank must be designed for the most unfavorable static heel angle within a 0° to 30° range without exceeding the allowable stress of the material.

(c) A hydrostatic or hydropneumatic test design load must be specially approved by the Commandant (G–MMT).

§ 154.407 Cargo tank internal pressure head.

(a) For the calculation required under § 154.406(a)(1) and (b), the internal pressure head (h_{eq}), must be determined from the following formula:

$$h_{eq} = 10\,P_o + (h_{eq})_{max}$$

where:

h_{eq} (the value of internal pressure, in meters of fresh water, resulting from the combined effects of gravity and dynamic accelerations of a full tank) $= a_\beta Z_\beta Y$

where:

a_β = dimensionless acceleration relative to the acceleration of gravity resulting from gravitational and dynamic loads in the β direction (see figure 1);

Z_β = largest liquid height (m) above the point where the pressure is to be determined in the β direction (see figure 2);

Y = maximum specific weight of the cargo (t/m^3) at the design temperature.

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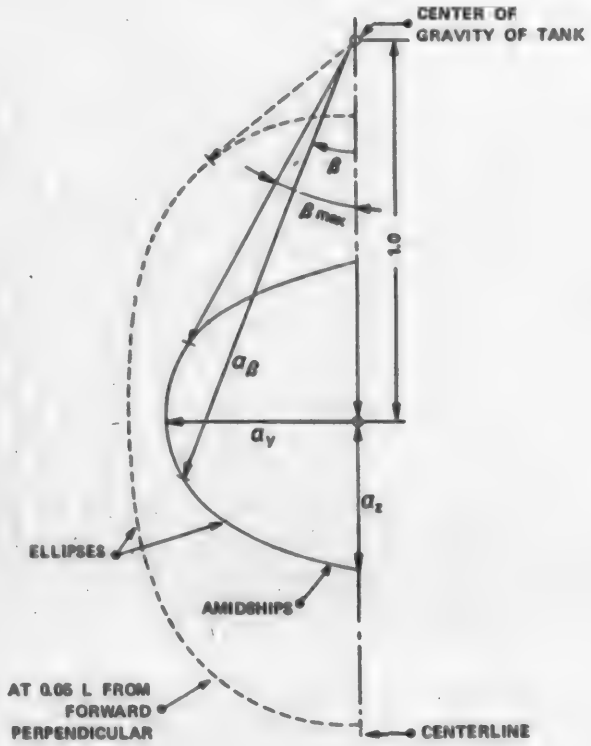

NOTE: RESULTING ACCELERATION (STATIC + DYNAMIC) = a_β IN ARBITRARY DIRECTION β.

a_y = TRANSVERSE COMPONENT OF ACCELERATION.

a_z = VERTICAL COMPONENT OF ACCELERATION.

Figure 1. Acceleration Ellipse

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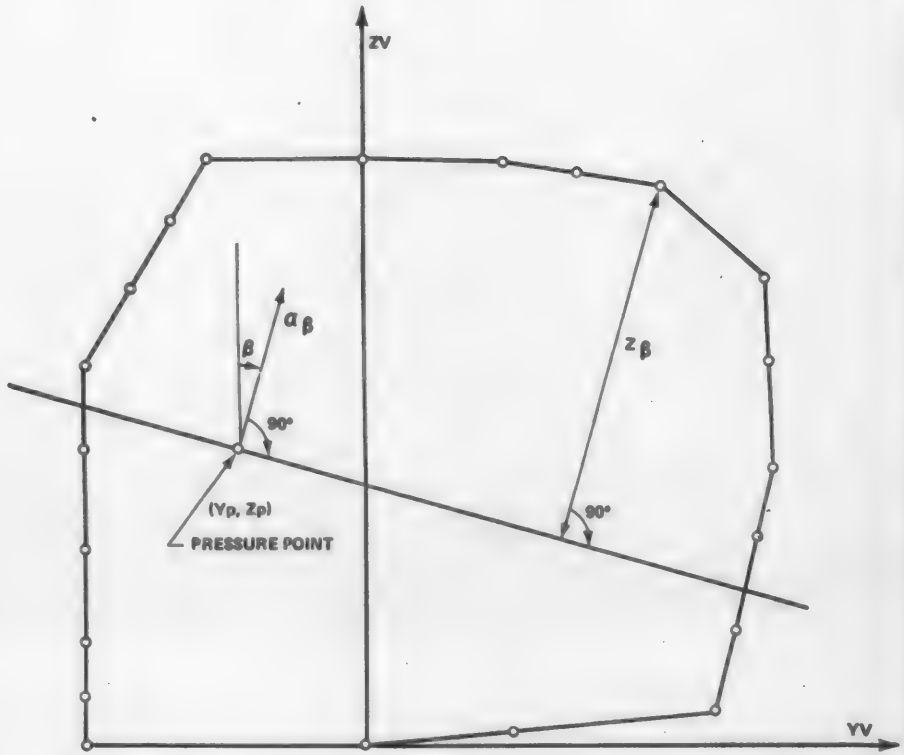

NOTE: LARGEST LIQUID HEIGHT ABOVE THE POINT WHERE THE PRESSURE IS DETERMINED = Z_β

Figure 2. Determination of Internal Pressure Heads

(b) The $(h_{sd})_{max}$ is determined for the β direction, on the ellipse in Figure 1, which gives the maximum value for h_{sd}.

(c) When the longitudinal acceleration is considered in addition to the vertical transverse acceleration, an ellipsoid must be used in the calculations instead of the ellipse contained in Figure 1.

§ 154.408 Cargo tank external pressure load.

For the calculation required under § 154.406 (a)(2) and (b), the external pressure load must be the difference between the minimum internal pressure (maximum vacuum), and the maximum external pressure to which any portion of the cargo tank may be simultaneously subjected.

§ 154.409 Dynamic loads from vessel motion.

(a) For the calculation required under § 154.406 (a)(3) and (b), the dynamic loads must be determined from the long term distribution of vessel motions, including the effects of surge, sway, heave, roll, pitch, and yaw on irregular seas that the vessel may experience during 10^8 wave encounters. The speed used for this calculation may be reduced from the ship service speed if specially approved by the Commandant (G–MMT) and if that reduced speed is used in the hull strength calculation under § 31.10–5(c) of this chapter.

(b) If the loads determined under paragraphs (c), (d), or (e) of this section result in a design stress that is lower than the allowable stress of the material under §§ 154.610, 154.615, or 154.620, the allowable stress must be reduced to that stress determined in paragraphs (c), (d), or (e).

(c) If a tank is designed to avoid plastic deformation and buckling, then acceleration components of the dynamic loads must be determined for the largest loads the vessel may experience during an operating life corresponding to the probability level of 10^{-8}, by using one of the following methods:

(1) Method 1 is a detailed analysis of the vessel's acceleration components.

(2) Method 2 applies to vessels of 50 m (164 ft) or more in length and is an analysis by the following formulae that corresponds to a 10^{-8} probability level in the North Atlantic:

(i) Vertical acceleration under § 154.409(f)(1):

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$$a_z = \pm a_o \sqrt{1 + \left(5.3 - \frac{45}{L_o}\right)^2 \left(\frac{x}{L_o} + 0.05\right)^2 \left(\frac{0.6}{C_B}\right)^{3/2}}$$

(ii) Transverse acceleration under § 154.409(f)(2):

$$a_y = \pm a_o \sqrt{0.6 + 2.5\left(\frac{x}{L_o} + 0.05\right)^2 + K\left(1 + 0.6K\frac{z}{B}\right)^2}$$

(iii) Longitudinal acceleration under § 154.409(f)(3):

$$a_x = \pm a_o \sqrt{0.06 + A^2 - 0.25A}$$

where:

$$A = \left(0.7 - \frac{L_o}{1200} + 5\frac{z}{L_o}\right)\left(\frac{0.6}{C_B}\right)$$

L_o = the distance in meters on the estimated summer loadline, from the fore side of the stem to the after side of the rudder-post or sternpost; where there is no rudderpost or sternpost, L_o is to be measured to the centerline of the rudder stock, but in any case L_o is not to be less than 96% and need not be greater than 97% of the length on the summer loadline.

C_B = block coefficent.

B = greatest moulded breadth, in meters.

x = longitudinal distance, in meters, from amidships to the center of gravity of the tank with contents (positive - forward of amidships, negative - aft of amidships).

z = vertical distance in meters, from the vessel's waterline, to center of gravity of tank with contents (positive - above, and negative - below the waterline).

$$a_o = 0.2\frac{V}{\sqrt{L_o}} + \frac{34 - (600/L_o)}{L_o}$$

V = service speed in knots.

K = L0 or $\frac{13GM}{B}$, whichever is greater.

GM = metacentric height in meters.

a_x = the maximum dimensionless acceleration in the x direction, acting separately for calculation purposes, and includes the component of the static weight in the longitudinal direction due to pitching.

a_y = maximum dimensionless acceleration in the y direction, acting separately for calculation purposes, and includes the component of static weight in the transverse direction due to rolling.

a_z = maximum dimensionless acceleration in the z direction, acting separately for calculation purposes, not including the static weight.

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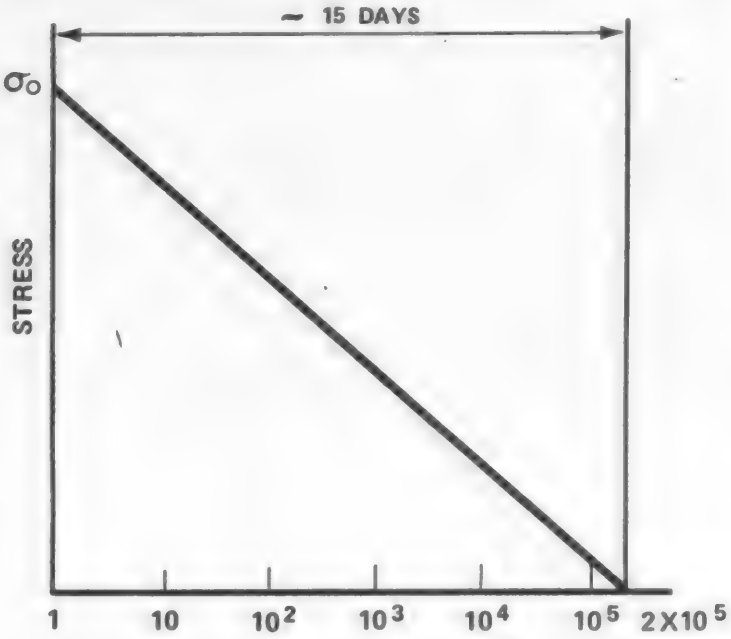
(d) If a cargo tank is designed to avoid fatigue, the dynamic loads determined under paragraph (a) of this section must be used to develop the dynamic spectrum.

(e) If a cargo tank is designed to avoid uncontrolled crack propagation, the dynamic loads are—

(1) Determined under paragraph (a) of this section; and

(2) For a load distribution for a period of 15 days by the method in Figure 3.



NOTE: σ_o = MOST PROBABLE MAXIMUM STRESS DURING THE LIFE OF THE VESSEL.

RESPONSE CYCLE SCALE IS LOGARITHMIC.

THE VALUE OF $2X10^5$ IS GIVEN AS AN EXAMPLE OF ESTIMATE.

Figure 3. Simplified Load Distribution

(f) When determining the accelerations for dynamic loads under paragraph (a) of this section, the accelerations acting in a cargo tank must be estimated for the cargo tank's center of gravity and include the following component accelerations:

(1) Vertical accelerations, meaning the motion acceleration of heave and pitch, and of any roll normal to the vessel base that has an effect on the component acceleration.

(2) Transverse acceleration, meaning the motion acceleration of sway, yaw and roll, and gravity component of roll.

(3) Longitudinal acceleration, meaning the motion acceleration of surge and pitch and gravity component of pitch.

§ 154.410 Cargo tank sloshing loads.

(a) For the calculation required under § 154.406(a)(5) and (b), the determined sloshing loads resulting from the accelerations under § 154.409(f) must be specially approved by the Commandant (G–MMT).

(b) If the sloshing loads affect the cargo tank scantlings, an analysis of the effects of the sloshing loads in addition to the calculation under paragraph (a) of this section must be specially approved by the Commandant (G–MMT).

§ 154.411 Cargo tank thermal loads.

For the calculations required under § 154.406(a)(4), the following determined loads must be specially approved by the Commandant (G–MMT):

(a) Transient thermal loads for the cooling down periods of cargo tanks for design temperatures lower than −55° C (−67° F).

(b) Stationary thermal loads for cargo tanks for design temperatures lower than −55° C (−67° F) that cause high thermal stress.

§ 154.412 Cargo tank corrosion allowance.

A cargo tank must be designed with a corrosion allowance if the cargo tank—

(a) is located in a space that does not have inert gas or dry air; or

(b) carries a cargo that corrodes the tank material.

Note.—Corrosion allowance for independent tank type C is contained in § 54.01–35 of this chapter.

Integral Tanks

§ 154.418 General.

An integral tank must not be designed for a temperature colder than −10° C (14° F), unless the tank is specially approved by the Commandant (G–MMT).

§ 154.419 Design vapor pressure.

The P_o of an integral tank must not exceed 24.5 kPa gauge (3.55 psig) unless special approval by the Commandant (G–MMT) allows a P_o between 24.5 kPa gauge (3.55 psig) and 69 kPa gauge (10 psig).

§ 154.420 Tank design.

(a) The structure of an integral tank must meet the deep tank scantling standards of the American Bureau of Shipping published in "Rules for Building and Classing Steel Vessels", 1976.

(b) The structure of an integral tank must be designed and shown by calculation to withstand the internal pressure determined under § 154.407.

§ 154.421 Allowable stress.

The allowable stress for the integral tank structure must meet the American Bureau of Shipping's allowable stress for the vessel's hull published in "Rules for Building and Classing Steel Vessels", 1976.

Membrane Tanks

§ 154.425 General.

The design of the hull structure and the design of the membrane tank system, that includes the membrane tank, secondary barrier, including

welds, the supporting insulation, and pressure control equipment, must be specially approved by the Commandant (G–MMT).

§ 154.426 Design vapor pressure.

The P_o of a membrane tank must not exceed 24.5 kPa gauge (3.55 psig) unless special approval by the Commandant (G–MMT) allows a P_o between 24.5 kPa gauge (3.55 psig) and 69 kPa gauge (10 psig).

§ 154.427 Membrane tank system design.

A membrane tank system must be designed for—

(a) Any static and dynamic loads with respect to plastic deformation and fatigue;

(b) Combined strains from static, dynamic, and thermal loads;

(c) Preventing collapse of the membrane from—

(1) Over-pressure in the interbarrier space;

(2) Vacuum in the cargo tank;

(3) Sloshing in a partially filled cargo tank; and

(4) Hull vibrations; and

(d) The deflections of the vessel's hull.

§ 154.428 Allowable stress.

The membrane tank and the supporting insulation must have allowable stresses that are specially approved by the Commandant (G–MMT).

§ 154.429 Calculations.

The tank design load calculations for a membrane tank must include the following:

(a) Plastic deformation and fatigue life resulting from static and dynamic loads in the membrane and the supporting insulation.

(b) The response of the membrane and its supporting insulation to vessel motion and acceleration under the worst weather conditions. Calculations from a similar vessel may be submitted to meet this paragraph.

(c) The combined strains from static, dynamic, and thermal loads.

§ 154.430 Material test.

(a) The membrane and the membrane supporting insulation must be made of materials that withstand the combined strains calculated under § 154.429(c).

(b) Analyzed data of a material test for the membrane and the membrane supporting insulation must be submitted to the Commandant (G–MMT).

§ 154.431 Model test.

(a) The primary and secondary barrier of a membrane tank, including the corners and joints, must withstand the combined strains from static, dynamic, and thermal loads calculated under § 154.429(c).

(b) Analyzed data of a model test for the primary and secondary barrier of the membrane tank must be submitted to the Commandant (G–MMT).

§ 154.432 Expansion and contraction.

The support system of a membrane tank must allow for thermal and physical expansion and contraction of the tank.

Semi-Membrane Tanks

§ 154.435 General.

(a) The design of a semi-membrane tank, the supporting insulation for the tank, and the supporting hull structure for the tank must be specially approved by the Commandant (G–MMT).

(b) A semi-membrane tank must be designed to meet—

(1) § 154.425 through § 154.432;

(2) § 154.437 through § 154.440; or

(3) § 154.444 through § 154.449.

§ 154.436 Design vapor pressure.

The P_o of a semi-membrane tank must not exceed 24.5 kPa gauge (3.55 psig) unless special approval by the Commandant (G–MMT) allows a P_o between 24.5 kPa gauge (3.55 psig) and 69 kPa gauge (10 psig).

Independent Tank Type A

§ 154.437 General.

An independent tank type A must meet § 154.438 through § 154.440.

§ 154.438 Design vapor pressure.

(a) If the surface of an independent tank type A are mostly flat surfaces, the P_o must not exceed 69 kPa gauge (10 psig).

(b) If the surfaces of an independent tank type A are formed by bodies of revolution, the design calculation of the P_o must be specially approved by the Commandant (G–MMT).

§ 154.439 Tank design.

An independent tank type A must meet the deep tank standard of the American Bureau of Shipping published in "Rules for Building and Classing Steel Vessels", 1976, and must—

(a) withstand the internal pressure determined under § 154.407;

(b) withstand loads from tank supports calculated under §§ 154.470 and 154.471; and

(c) have a corrosion allowance that meets § 154.412.

§ 154.440 Allowable stress.

(a) The allowable stresses for an independent tank type A must—

(1) for tank web frames, stringers, or girders of carbon manganese steel or aluminum alloys, meet $\sigma_u/2.66$ or $\sigma_Y/1.33$, whichever is less; and

(2) for other materials, be specially approved by the Commandant (G–MMT).

(b) A greater allowable stress than required in paragraph (a)(1) of this section may be specially approved by the Commandant (G–MMT) if the equivalent stress (σ_e) is calculated from the formula in Appendix A of this part.

(c) Tank plating must meet the American Bureau of Shipping's deep tank standards, for an internal pressure head that meets § 154.439(a), published in "Rules for Building and Classing Steel Vessels", 1976.

Independent Tank Type B

§ 154.444 General.

An independent tank type B must be designed to meet §§ 154.445 through 154.449.

§ 154.445 Design vapor pressure.

If the surfaces of an independent tank type B are mostly flat surfaces, the P_o must not exceed 69 kPa gauge (10 psig).

§ 154.446 Tank design.

An independent tank type B must meet the calculations under § 154.448.

§ 154.447 Allowable stress.

(a) An independent tank type B designed from bodies of revolution must have allowable stresses [3] determined by the following formulae:

$\sigma_m \leq f$
$\sigma_L \leq 1.5\,f$
$\sigma_b \leq 1.5\,F$
$\sigma_L + \sigma_b \leq 1.5\,F$
$\sigma_m + \sigma_b \leq 1.5\,F$

Where:

σ_m = equivalent primary general membrane stress [4]
σ_L = equivalent primary local membrane stress [4]
σ_b = equivalent primary bending stress [4]
f = the lesser of (σ_u/A) or (σ_Y/B)
F = the lesser of (σ_u/C) or (σ_Y/D)
A, B, C, and D = stress factors in Table 2.

Table 2.—Values for Stress Factors

	Nickel steel and carbon manganese steel values	Austenitic steel values	Aluminum alloy values
Stress factors:			
A	4.0	4.0	4.0
B	2.0	1.6	1.5
C	3.0	3.0	3.0
D	1.5	1.5	1.5

(b) An independent tank type B designed from plane surfaces must have

[3] See Appendix B for stress analyses definitions.
[4] See Appendix A for equivalent stress.

allowable stresses specially approved by the Commandant (G–MMT).

§ 154.448 Calculations.

The following calculations for an independent tank type B must be specially approved by the Commandant (G–MMT):

(a) Plastic deformation, fatigue life, buckling, and crack propagation resulting from static and dynamic loads on the tank and its support.

(b) A three-dimensional analysis of the stress exerted by the hull on the tank, its its support, and its keys.

(c) The response of the tank and its support to the vessel's motion and acceleration in irregular waves or caculations from a similar vessel.

(d) A tank buckling analysis considering the maximum construction tolerance.

(e) A finite element analysis using the loads determined under § 154.406.

(f) A fracture mechanics analysis using the loads determined under § 154.406.

(g) The cumulative effects of the fatigue load from the following formula:

$$\sum \frac{n_i}{N_i} + \frac{10}{N_j}^3 \leq C_w$$

Where:

n_i = the number of stress cycles at each stress level during the life of the vessel;

N_i = the number of cycles to failure for corresponding stress levels from the Wohler (S–N) curve;

N_j = the number of cycles to failure from the fatigue load by loading and unloading the tank; and

C_w = 0.5 or less. A C_w of greater than 0.5 but not exceeding 1.0 may be specially approved by the Commandant (G–MMT).

§ 154.449 Model test.

The following analyzed data of a model test of structural elements for independent tank type B must be submitted to the Commandant (G–MMT) for special approval:

(a) Stress concentration factors.

(b) Fatigue life.

Independent Tank Type C and Process Pressure Vessels

§ 154.450 General.

Independent tanks type C and process pressure vessels must be designed to meet the requirements under Part 54 of this chapter, except § 54.01–40(b), and—

(a) The calculation under § 54.01–18 (b)(1) must also include the design loads determined under § 154.406;

(b) The calculated tank plating thickness, including any corrosion allowance, must be the minimum thickness without a negative plate tolerance; and

(c) The minimum tank plating thickness must not be less than—

(1) 5mm (3/16 in.) for carbon-manganese steel and nickel steel;

(2) 3mm (1/8 in.) for austenitic steels; or

(3) 7mm (9/32 in.) for aluminum alloys.

§ 154.451 Design vapor pressure.

The P_o (kPa) of an independent tank type C must be calculated by the following formula:

$P_o = 196 + AC(\rho)^{3/2}$

Where:

$A = 1.813 (\sigma_m/\Delta\sigma_A)^2$;

σ_m = design primary membrane stress;

$\Delta\sigma_A$ = (allowable dynamic membrane stress for double amplitude at probability level $Q = 10^{-8}$) 53.9 MPa (7821 psi) for ferritic and martensitic steels and 24.5 MPa (3555 psi) for 5083–0 aluminum;

C = a characteristic tank dimension that is the greatest of h, 0.75b, or 0.45 l;

Where:

h = the height of the tank or the dimension in the vessel's vertical direction, in meters;

b = the width of the tank or the dimension in the vessel's transverse direction; in meters; and

l = the length of the tank or the dimension in the vessel's longitudinal direction, in meters; and

ρ = the specific gravity of the cargo.

§ 154.452 External pressure.

The design external pressure, P_e, for an independent tank type C must be calculated by the following formula

$P_e = P_1 + P_2 + P_3 + P_4$

where:

P_1 = the vacuum relief valve setting for tanks with a vacuum relief valve, or 24.5 kPa guage (3.55 psig) for tanks without a vacuum relief valve.

P_2 = 0, or the pressure relief valve setting for an enclosed space containing any portion of a pressure vessel.

P_3 = total compressive load in the tank shell from the weight of the tank, including corrosion allowance, weight of insulation, weight of dome, weight of pipe tower and piping, the effect of the partially filled tank, the effect of acceleration and hull deflection, and the local effect of external and internal pressure.

P_4 = 0, or the external pressure from the head of water from any portion of the pressure vessel on exposed decks.

§ 154.453 Failure to meet independent tank type C standards.

If the Commandant (G–MMT) determines during plan review, that a tank designed as an independent tank type C fails to meet the standards under §§ 154.450, 154.451, and 154.452 and can not be redesigned to meet those standards, the tank may be redesigned as an independent tank type A or B.

Secondary Barrier

§ 154.459 General

(a) Each cargo tank must have a secondary barrier that meets Table 3 and except as allowed in Table 3, the hull must not be in the secondary barrier.

(b) If the Commandant (G–MMT) specially approves an integral tank for a design temperature at atmospheric pressure lower than −10° C (14° F), the integral tank must have a complete secondary barrier that meets § 154.460.

(c) If the Commandant (G–MMT) specially approves a semi-membrane tank under the requirements of an independent tank type B, the semi-membrane tank may have a partial secondary barrier specially approved by the Commandant (G–MMT).

(d) If Table 3 allows the hull to be a secondary barrier, the vessel's hull must—

(1) Meet §§ 154.605 through 154.630; and

(2) Be designed for the stresses resulting from the design temperature.

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Table 3 - Secondary Barriers for Tanks

Tank Type	Cargo Temperature (T) at Atmospheric Pressure		
	$T \geq -10^{\circ}C$ ($14^{\circ}F$)	$T < -10^{\circ}C$ ($14^{\circ}F$) $\geq -55^{\circ}C$ ($-67^{\circ}F$)	$T < -55^{\circ}C$ ($-67^{\circ}F$)
Integral	No Secondary Barrier required	Tank type not usually allowed[1]	Tank type not allowed
Membrane	Ditto	Complete secondary barrier[1]	Complete secondary barrier
Semi-membrane	Ditto	Complete secondary barrier[1]	Complete secondary barrier
Independent			
Type A	Ditto	Complete secondary barrier[1]	Complete secondary barrier
Type B	Ditto	Partial Secondary barrier[1]	Partial secondary barrier
Type C	Ditto	No secondary barrier required	No secondary barrier required

[1]The hull may be a secondary barrier.

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§ 154.460 Design criteria.

At static angles of heel up through 30°, a secondary barrier must

(a) If a complete secondary barrier is required in § 154.459, hold all of the liquid cargo in the cargo tank for at least 15 days under the dynamic loads in § 154.409(e);

(b) If a partial secondary barrier is permitted in § 154.459, hold any leakage of liquid cargo corresponding to the extent of failure under § 154.448(a) after initial detection or primary barrier leak for at least 15 days under the dynamic loads in § 154.409(e);

(c) If the primary barrier fails, prevent the temperature of the vessel's structure from falling below the minimum allowable service temperature of the steel; and

(d) Be designed so that a cargo tank failure does not cause a failure in the secondary barrier.

Insulation

§ 154.465 General.

If the design temperature is below −10° C (14° F), the cargo tank insulation must prevent the temperature of the vessel's hull from cooling below the minimum temperature allowed under § 154.172.

§ 154.466 Design criteria.

(a) The insulation for a cargo tank without a secondary barrier must be designed for the cargo tank at the design temperature, and for a vessel operating in—

(1) Any waters in the world, except Alaskan waters, for the ambient cold condition of—

(i) Five knots air at −18° C (0° F); and

(ii) Still sea water at 0° C (32° F); or

(2) Alaskan waters for the ambient cold condition of—

(i) Five knots air at −29° C (20° F); and

(ii) Still sea water at −2° C (28° F).

(b) The insulation for a cargo tank with a secondary barrier must be designed for the secondary barrier at the design temperature, and the ambient cold conditions listed under paragraph (a)(1) or paragraph (a)(2) of this section.

(c) The insulation material must be designed for any loads transmitted from adjacent hull structure.

(d) Insulation for cargo tank and piping must meet § 38.05–20 of this chapter.

(e) Powder or granulated insulation must—

(1) Not compact from vibrations of the vessel;

(2) Maintain the thermal conductivity listed under § 154.467; and

(3) Not exert a static pressure greater than the external design pressure of the cargo tank under § 154.408.

§ 154.467 Submission of insulation information.

The following insulation information must be submitted for special approval by the Commandant (G–MMT):

(a) Compatibility with the cargo.

(b) Solubility in the cargo.

(c) Absorption of the cargo.

(d) Shrinkage.

(e) Aging.

(f) Closed cell content.

(g) Density.

(h) Mechanical properties.

(i)Thermal expansion.

(j) Abrasion.

(k) Cohesion.

(l) Thermal conductivity.

(m) Resistance to vibrations.

(n) Resistance to fire and flame spread.

(o) The manufacturing and installation details of the insulation including—

(1) fabrication;

(2) storage;

(3) handling;

(4) erection; and

(5) quality control.

Support System

§ 154.470 General.

(a) A cargo tank must have a support system that—

(1) prevents movement of the cargo tank under the static and dynamic loads in § 154.408; and

(2) allows the cargo tank to contract and expand from temperature variation and hull deflection without exceeding the design stress of the cargo tank and the hull.

(b) The cargo tank support system must have a key that prevents rotation of the cargo tank.

(c) An independent tank must have supports with an antiflotation system that withstands the upward force of the tank without causing plastic deformation that endangers the hull structure when the tank is—

(1) Empty; and

(2) In a hold space flooded to the summer load draft of the vessel.

§ 154.471 Design criteria.

(a) The cargo tank support system must be designed—

(1) For the loads in § 154.408(a);

(2) To not exceed the allowable stress under this part at a static angle of heel of 30°;

(3) To withstand a collision force equal to at least one-half the weight of the cargo tank and cargo from forward and one-quarter the weight of the cargo tank and cargo from aft; and

(4) For the largest resulting acceleration in Figure 1, including rotational and translation effects.

(b) The cargo tank support design loads in paragraph (a) of this section may be analyzed separately.

§ 154.476 Cargo transfer devices and means.

(a) If a cargo pump in a cargo tank is not accessible for repair when the cargo tank is in use, the cargo tank must have an additional means of cargo transfer, such as another pump or gas pressurization.

(b) If cargo is transferred by gas pressurization, the pressurizing line must have a safety relief valve that is set at less than 90 percent of the tank relief valve setting.

Cargo and Process Piping Systems

§ 154.500 Cargo and process piping standards.

The cargo liquid and vapor piping and process piping systems must meet the requirements in §§ 154.503 through 154.562, Subparts 56.01 through 56.35, §§ 56.50–20 and 56.50–105, and Subparts 56.60 through 56.97 of this chapter.

§ 154.503 Piping and piping system components: protection from movement.

Where thermal movement and movements of the cargo tank and the hull structure may cause stresses that exceed the design stresses, the piping and piping system components and cargo tanks must be protected from movement by—

(a) Offsets;

(b) Loops;

(c) Bends;

(d) Mechanical expansion joints including—

(1) Bellows;

(2) Slip joints;

(3) Ball joints; or

(e) Other means specially approved by the Commandant (G–MMT).

§ 154.506 Mechanical expansion joint: limits in a piping system.

Mechanical expansion joints in a piping system outside of a cargo tank—

(a) May be installed only if offsets, loops or bends cannot be installed due to limited space or piping arrangement;

(b) Must be a bellows type; and

(c) Must not have insulation or a cover unless necessary to prevent damage.

§ 154.512 Piping: thermal isolation.

Low temperature piping must be thermally isolated from any adjacent hull structure to prevent the temperature

of that structure from dropping below the minimum temperature for the hull material under § 154.170.

§ 154.514 Piping: electrical bonding.

(a) Cargo tanks or piping that are separated from the hull structure by thermal isolation must be electrically bonded to the hull structure by a method under paragraph (c) of this section.

(b) A pipe joint or a hose connection fitting that has a gasket must be electrically bonded by a method under paragraph (c) of this section that bonds—

(1) Both sides of the connection to the hull structure; or

(2) Each side of the connection to the other side.

(c) An electrical bond must be made by at least one of the following methods:

(1) A metal bonding strap attached by welding or bolting.

(2) Two or more bolts that give metal to metal contact between the bolts and the parts to be bonded.

(3) Metal to metal contact between adjacent parts under designed operating conditions.

§ 154.516 Piping: hull protection.

A vessel's hull must be protected from low temperature liquid leakage by a drip pan, or other means specially approved by the Commandant (G–MMT), at—

(a) Each piping connection dismantled on a routine basis;

(b) Cargo discharge and loading manifolds; and

(c) Pump seals.

§ 154.517 Piping: liquid pressure relief.

The cargo loading and discharge crossover headers, cargo hoses, and cargo loading arms must have means to relieve cargo pressure and to remove liquid cargo.

§ 154.519 Piping relief valves.

(a) The liquid relief valve that protects the cargo piping system from liquid pressure exceeding the design pressure must discharge into—

(1) A cargo tank; or

(2) A cargo vent mast if that vent mast has a means for the detection and removal of the liquid cargo that is specially approved by the Commandant (G–MMT).

(b) A relief valve on a cargo pump that protects the cargo piping system must discharge into the pump suction.

§ 154.520 Piping calculations.

A piping system must be designed to meet the allowable stress values under § 56.07–10 of this chapter and, if the design temperature is −110° C (−166° F) or lower, the stress analysis must be specially approved by the Commandant (G–MMT) and must include—

(a) Pipe weight loads;

(b) Acceleration loads;

(c) Internal pressure loads;

(d) Thermal loads; and

(e) Loads from the hull.

§ 154.522 Materials for piping.

(a) The materials for piping systems must meet § 154.625 for the minimum design temperature of the piping, except the material for open ended vent piping may be specially approved by the Commandant (G–MMT) if—

(1) The temperature of the cargo at the pressure relief valve setting is −55° C (−67° F) or warmer; and

(2) Liquid can not discharge to the vent piping.

(b) Materials for piping outside the cargo tanks must have a melting point of at least 925° C (1697° F), except for short lengths of pipes with fire resisting insulation that are attached to the cargo tanks.

§ 154.524 Piping joints: welded and screwed couplings.

Pipe lengths without flanges must be joined by one of the following:

(a) A butt welded joint with complete penetration at the weld root except that for design temperatures colder than −10° C (14° F) the butt weld must be double welded or must be welded using a—

(1) A backing ring that for design pressures greater than 979 kPa gauge (142 psig) must be removed after the weld is completed;

(2) A consumable insert; or

(3) An inert gas back-up on the first weld pass.

(b) A slip-on welded joint with sleeves and attachment welds is allowed for an open ended pipe with an external diameter of 50 mm (2 in.) or less and a design temperature of −55° C (−67° F), or warmer.

(c) A socket weld fitting with attachment welds is allowed for pipe with an external diameter of 50 mm (2 in.) or less and a design temperature of −55° C (−67° F) or warmer.

(d) Screwed couplings are allowed for instrumentation and control piping that meets § 56.30–20 and § 56.50–105 (a)(4) and (b)(4) of this chapter.

(e) A method or fitting specially approved by the Commandant (G–MMT).

§ 154.526 Piping joints: flange connection.

Flange connections for pipe joints must meet § 56.30–10 and § 56.50–105 (a)(4) and (b)(4) of this chapter.

§ 154.528 Piping joints: flange type.

(a) A flange must be one of the following types:

(1) Welding neck.

(2) Slip-on.

(3) Socket weld.

(b) If the piping is designed for a temperature between −10° C (14° F) and −55° C (−67° F), the pipe flange may be—

(1) Slip-on type, if the nominal pipe size is 100 mm (4 in.) or less;

(2) Socket weld, if the nominal pipe size is 50 mm (2 in.) or less; or

(3) Welding neck.

(c) If the piping is designed for a temperature lower than −55° C (−67° F), the pipe flange must be a welding neck type.

§ 154.530 Valves: cargo tank MARVS 69 kPa gauge (10 psig) or lower.

(a) Except connections for tank safety relief valves and except for liquid level gauging devices other than those under §§ 154.536 and 154.1310, liquid and vapor connections on a cargo tank with a MARVS of 69 kPa gauge (10 psig) or lower must have shut-off valves, as defined in § 154.3, that—

(1) Are located as close to the tank as practical;

(2) Are capable of local manual operation; and

(3) May be remotely controlled.

(b) The cargo piping system for a cargo tank with a MARVS of 69 kPa gauge (10 psig) or lower must have at least one remotely controlled quick-closing shut-off valve for closing liquid and vapor piping between vessel and shore that meets §§ 154.540 and 154.544.

§ 154.532 Valves: cargo tank MARVS greater than 69 kPa gauge (10 psig).

(a) Except connections for tank safety relief valves and except for liquid level gauging devices other than those under §§ 154.536 and 154.1310, liquid and vapor connections on a cargo tank with a MARVS greater than 69 kPa gauge (10 psig) must have, as close to the tank as practical, a—

(1) Stop valve capable of local manual operation; and

(2) A remotely controlled quick-closing shut-off valve.

(b) If the nominal pipe size of a liquid or vapor connection is less than 50 mm (2 in.), an excess flow valve may be substituted for the quick-closing valve under paragraph (a) of this section.

(c) One valve may be substituted for the manual controlled stop valve and the remotely controlled quick-closing shut-off valve required under paragraph (a) of this section if that valve—

(1) Meets §§ 154.540 and 154.544; and

(2) Is capable of local manual operation.

§ 154.534 Cargo pumps and cargo compressors.

Cargo pumps and cargo compressors must shut-down automatically when the quick-closing shut-off valves under §§ 154.530 and 154.532 are closed by the emergency shut-down system required under § 154.540.

§ 154.536 Cargo tank gauging and measuring connections.

Unless the outward flow from a cargo tank is less than the flow through a circular hole of 1.4 mm (0.055 in.) in diameter, cargo tank connections for gauging or measuring devices must have the excess flow, shut-off, or quick-closing shut-off valves under §§ 154.530 or 154.532.

§ 154.538 Cargo transfer connection.

A cargo transfer connection must have a—

(a) Remotely controlled quick-closing shut-off valve that meets §§ 154.540 and 154.544; or

(b) Blank flange.

§ 154.540 Quick-closing shut-off valves: emergency shut-down system.

The quick-closing shut-off valves under §§ 154.530, 154.532, and 154.538 must have an emergency shut-down system that—

(a) Closes all the valves;

(b) Is actuated by a single control in at least two locations remote from the quick-closing valves;

(c) Is actuated by a single control in each cargo control station under § 154.320; and

(d) Has fusible elements at each tank dome and cargo loading and discharge manifold that melt between 98° C (208° F) and 104° C (220° F) and actuate the emergency shut-down system.

§ 154.544 Quick-closing shut-off valves.

The quick-closing shut-off valve under §§ 154.530, 154.532 and 154.538 must—

(a) Be a shut-off valve as defined in § 154.3;

(b) Close from the time of actuation in 30 seconds or less;

(c) Be the fail-closed type; and

(d) Be capable of local manual closing.

§ 154.546 Excess flow valve: closing flow.

(a) The rated closing flow of vapor or liquid cargo for an excess flow valve must be specially approved by the Commandant (G–MMT).

(b) An excess flow valve allowed under § 154.532(b) must close automatically at the rated closing flow.

§ 154.548 Cargo piping: flow capacity.

Piping with an excess flow valve must have a vapor or liquid flow capacity that is greater than the rated closing flow under § 154.546.

§ 154.550 Excess flow valve: bypass.

If the excess flow valve allowed under § 154.532(b) has a bypass, the bypass must be of 1.0 mm (0.0394 in.) or less in diameter.

Cargo Hose

§ 154.551 Cargo hose: general.

Each of the vessel's liquid and vapor cargo hose for loading or discharging cargo must meet §§ 154.552 through 154.562.

§ 154.552 Cargo hose: compatibility.

Liquid and vapor cargo hoses must—

(a) Not chemically react with the cargo; and

(b) Withstand design temperature.

§ 154.554 Cargo hose: bursting pressure.

Cargo hose that may be exposed to the pressure in the cargo tank, the cargo pump discharge, or the vapor compressor discharge must have a bursting pressure of at least five times the maximum working pressure on the hose during cargo transfer.

§ 154.556 Cargo hose: maximum working pressure.

A cargo hose must have a maximum working pressure not less than the maximum pressure to which it may be subjected and at least 1034 kPa gauge (150 psig).

§ 154.558 Cargo hose: marking.

Each cargo hose must be marked with the—

(a) Maximum working pressure; and

(b) Minimum service temperature for service at other than ambient temperature.

§ 154.560 Cargo hose: prototype test.

(a) Each cargo hose must be of a type that passes a prototype test at a pressure of at least five times its maximum working pressure at or below the minimum service temperature.

(b) Each cargo hose must not be the hose used in the prototype test.

§ 154.562 Cargo hose: hydrostatic test.

Each cargo hose must pass a hydrostatic pressure test at ambient temperature of at least one and a half times its specified maximum working pressure but not more than two-fifths its bursting pressure.

Materials

§ 154.605 Toughness test.

(a) Each toughness test under §§ 154.610 through 154.625 must meet Subpart 54.05 of this chapter.

(b) If subsize test specimens are used for the Charpy V-notch toughness test, the Charpy V-notch energy must meet Table 54.05–20 (a) of this chapter.

§ 154.610 Design temperature not colder than 0° C (32° F).

Materials for cargo tanks for a design temperature not colder than 0° C (32° F) must meet the following:

(a) The tank materials must meet §§ 54.25–1 and 54.25–3 of this chapter.

(b) Plates, forgings, rolled and forged bars and shapes must be carbon manganese steel or other material allowed under §§ 154.615, 154.620, and 154.625.

(c) Plates must be normalized or quenched and tempered and where the thickness exceeds 20 mm (0.787 in.), made with fine grain practice, austenitic grain size of five or finer. A control rolling procedure may be substituted for normalizing if specially approved by the Commandant (G–MMT). Plate for an independent tank type C must also meet the requirements of ASTM A–20–75 and § 54.01–18(b)(5) of this chapter.

(d) For integral and independent type A tanks, the American Bureau of Shipping's grade D not exceeding 20 mm (0.787 in.) in thickness, and Grade E hull structural steel are allowed if the steel meets § 54.05–10 of this chapter.

(e) The tensile properties under paragraph (a) of this section must be determined for—

(1) Each plate as rolled; and

(2) Each five short ton batch of forgings, forged or rolled fittings, and forged or rolled bars and shapes.

(f) The specified yield strength must not exceed 637 MPa (92.43 Ksi) and when it exceeds 490 MPa (71.10 Ksi), the hardness of the weld and the heat affected zone must be specially approved by the Commandant (G–MMT).

(g) The Charpy V-notch impact energy must be determined for—

(1) Each plate as rolled; and

(2) Each five short ton batch of forgings, forged or rolled fittings and rolled or forged bars and shapes.

(h) The orientation and required impact energy of a 10 mm x 10 mm (0.394 in. x 0.394 in.) Charpy V-notch specimen must be—

(1) For plates; transverse specimen and 27.4 J (20 ft-lbs); and

(2) For forgings, forged and rolled fittings and rolled and forged bars:

longitudinal specimen and 41.1 J (30 ft-lbs).

(i) The test temperature of the Charpy V-notch specimens is as follows:

Material Thickness	Test Temperature
t≤ 20 mm (0.788 in.)	0° C (32° F)
20<t≤ 30 mm (1.182 in.)	−20° C (−4° F)
30<t≤40 mm (1.576 in.)	−40° C (−40° F)

§ 154.615 Design temperature below 0° C (32° F) and down to −55° C (−67° F).

Plates, forgings, forged or rolled or forged bars and shapes for cargo tanks and secondary barriers for a design temperature below 0° C (32° F) and down to −55° C (−67° F) must meet § 54.25–10 of this chapter.

§ 154.620 Design temperature below −55° C (−67° F) and down to −165° C (−265° F).

Plates, forgings and forged or rolled fittings, and rolled, forged or extruded bars and shapes for cargo tanks, secondary barriers, and process pressure vessels for a design temperature below −55° C (−67° F) and down to −165° C (−265° F) must—

(a) Meet § 54.25–10(b)(2), § 54.25–15, or § 54.25–20 of this chapter; or

(b) Be of an aluminum alloy that is specially approved by the Commandant (G–MMT).

§ 154.625 Design temperature below 0° C (32° F) and down to −165° C (−265° F).

Pipes, tubes, forgings, castings, bolting, and nuts for cargo and process piping for a design temperature below 0° C (32° F) and down to −165° C (−265° F) must meet § 56.50–105 of this chapter.

§ 154.630 Cargo tank material.

(a) If a material of a cargo tank is not listed in §§ 154.610, 154.615 or 154.620, the allowable stress of that material must be specially approved by the Commandant (G–MMT).

(b) For cargo tanks of aluminum alloys with welded connections, the minimum tensile strength (σ_s) for the calculations under § 154.440, § 154.447 and § 154.450 must be the minimum tensile strength of the alloy in the annealed condition.

(c) Increased yield strength and tensile strength of a material at low temperature for independent tanks type A, B, and C must be specially approved by the Commandant (G–MMT).

Construction

§ 154.650 Cargo tank and process pressure vessel welding.

(a) Cargo tank and process pressure vessel welding must meet Subpart 54.05 and Part 57 of this chapter.

(b) Welding consumables used in welding cargo tanks must meet § 57.02–4 of this chapter.

(c) Independent tanks must meet the following:

(1) Each welded joint of the shells must be a full penetration butt weld, except dome to shell connections may have full penetration tee welds.

(2) Each nozzle weld must be of the full penetration type, except for small penetrations on domes.

(d) Each welded joint in an independent tank type C or in a process pressure vessel must meet Part 54 of this chapter, except that any backing rings must be removed unless specially approved by the Commandant (G–MMT).

(e) Each welded joint in a membrane tank must meet the quality assurance measures, weld procedure qualification, design details, materials, construction, inspection, and production testing of components developed during the prototype testing program that are specially approved by the Commandant (G–MMT) under this part.

(f) Each welded joint in a semi-membrane tank must meet paragraph (c) or (e) of this section.

§ 154.655 Stress relief for independent tanks type C.

For a design temperature colder than −10° C (14° F), an independent tank type C of—

(a) Carbon and carbon-manganese steel must be stress relieved by post-weld heat treatment under § 54.25–7 of this chapter or by mechanical stress relief under Subpart 54.30 of this chapter; or

(b) Materials other than carbon and carbon manganese steel must be stress relieved as required under Part 54 of this chapter. The procedure for stress relieving must be specially approved by the Commandant (G–MMT).

§ 154.660 Pipe welding.

(a) Pipe welding must meet Part 57 of this chapter.

(b) Longitudinal butt welds, in piping that does not meet a standard or specification under § 56.60–1 of this chapter, and girth butt welds must meet the following:

(1) Butt welds of pipes made from carbon, carbon manganese, or low alloy steels must meet § 56.50–105 of this chapter, including the requirements for post-weld heat treatment.

(2) Except for piping inside an independent cargo tank type A, B, or C, butt welds must be 100% radiographically tested if the design temperature is lower than −10° C (14° F), and—

(i) The wall thickness is greater than 10 mm (0.394 in.); or

(ii) The nominal pipe diameter is greater than 100 mm (nominal 4 in.).

(3) If Table 4 references this section, butt welds for deck cargo piping exceeding 75 mm (3 in.) in diameter must be 100% radiographically tested.

(4) Butt welds of pipes not meeting paragraph (b)(2) or (b)(3) of this section must meet the non-destructive testing requirements under Subpart 56.95 of this chapter.

§ 154.665 Welding procedures.

Welding procedure tests for cargo tanks for a design temperature colder than 0° C (32° F), process pressure vessels, and piping must meet § 54.05–15 and Subpart 57.03 of this chapter.

Cargo Pressure and Temperature Control

§ 154.701 Cargo pressure and temperature control: General.

Except as allowed under § 154.703, cargo tanks must—

(a) Have their safety relief valves set at a pressure equal to or greater than the vapor pressure of the cargo at 45° C (113° F) but not greater than the MARVS under § 154.405; or

(b) Be refrigerated by a system meeting § 154.702, and each refrigerated incompatible cargo refrigerated by a separate system.

§ 154.702 Refrigerated carriage.

(a) Each refrigeration system must—

(1) Have enough capacity to maintain the cargo vapor pressure in each cargo tank served by the system below the set pressure of the relief valves under ambient temperatures of 45° C (113° F) still air and 32° C (89.6° F) still water with the largest unit in the system inoperative; or

(2) Have a standby unit with a capacity at least equal to the capacity of the largest refrigeration unit in the system.

(b) For the purpose of this section, a "refrigeration unit" includes a compressor and its motors and controls.

(c) Each refrigeration system must—

(1) Have a heat exchanger with an excess capacity of 25 percent of the required capacity; or

(2) A standby heat exchanger.

(d) Where cooling water is used in a refrigeration system—

(1) The cooling water pump or pumps must be used exclusively for the system;

(2) Each pump must have suction lines from sea chests on the port and starboard sides of the vessel; and

(3) There must be a standby pump, that may be used for—

(i) Non-essential purposes on the vessel; or

(ii) Essential purposes on the vessel, if the pump is sized to simultaneously provide for the capacity requirements for the essential purposes and the refrigeration cooling water.

(e) Each refrigeration system must use refrigerants that are compatible with the cargo and, for cascade units, with each other.

(f) The pressure of the heat transfer fluid in each cooling coil in a tank must be greater than the pressure of the cargo.

§ 154.703 Methane(LNG).

Unless a cargo tank carrying methane (LNG) can withstand the pressure build up due to boil-off for 21 days, the pressure in the cargo tank must be maintained below the set pressure of the safety relief valve for at least 21 days by—

(a) A refrigeration system that meets § 154.702;

(b) A waste heat or catalytic furnace that burns boil-off gas, and—

(1) Maintains the stack exhaust temperature below 535°C (995°F);

(2) Exhibits no visible flame; and

(3) Is specially approved by the Commandant (G–MMT);

(c) Boilers, inert gas generators, and combustion engines in the main propelling machinery space that use boil-off gas as fuel; or

(d) Equipment for services, other than those under paragraph (c) of this section, that use boil-off gas as fuel and that are located—

(i) In the main propelling machinery space; or

(ii) a space specially approved by the Commandant (G–MMT).

§ 154.705 Cargo boil-off as fuel: general.

(a) Each cargo boil-off fuel system under § 154.703(c) must meet §§ 154.706 through 154.709.

(b) The piping in the cargo boil-off fuel system must have a connection for introducing inert gas and for gas freeing the piping in the machinery space.

(c) A gas fired main propulsion boiler or combustion engine must have a fuel oil fired pilot that maintains fuel flow as required under § 154.1854 if the gas fuel supply is cut-off.

§ 154.706 Cargo boil-off as fuel: fuel lines.

(a) Gas fuel lines must not pass through accommodation, service, or control spaces. Each gas fuel line passing through other spaces must have a master gas fuel valve and meet one of the following:

(1) The fuel line must be a double-walled piping system with the annular space containing an inert gas at a pressure greater than the fuel pressure. Visual and audible alarms must be installed at the machinery control station to indicate loss of inert gas pressure.

(2) The fuel line must be installed in a mechanically exhaust-ventilated pipe or duct, having a rate of air change of at least 30 changes per hour. The pressure in the space between the inner pipe and outer pipe or duct must be maintained at less than atmospheric pressure. Continuous gas detection must be installed to detect leaks in the ventilated space. The ventilation system must meet § 154.1205.

(b) Each double wall pipe or vent duct must terminate in the ventilation hood or casing under § 154.707(a). Continuous gas detection must be installed to indicate leaks in the hood or casing.

§ 154.707 Cargo boil-off as fuel: ventilation.

(a) A ventilation hood or casing must be installed in areas occupied by flanges, valves, and piping at the fuel burner to cause air to sweep across them and be exhausted at the top of the hood or casing.

(b) The hood or casing must be mechanically exhaust-ventilated and meet § 154.1205.

(c) The ventilated hood or casing must have an airflow rate specially approved by the Commandant.

§ 154.708 Cargo boil-off as fuel: valves.

(a) Gas fuel lines to the gas consuming equipment must have two fail-closed automatic valves in series. A third valve, designed to fail-open, must vent that portion of pipe between the two series valves to the open atomosphere.

(b) The valves under paragraph (a) of this section must be arranged so that loss of boiler forced draft, flame failure, or abnormal gas fuel supply pressure automatically causes the two series valves to close and the vent valve to open. The function of one of the series valves and the vent valve may be performed by a single three-way valve.

(c) A master gas fuel valve must be located outside the machinery space, but be operable from inside the machinery space and at the valve. The valve must automatically close when there is—

(1) A gas leak detected under § 154.706(a)(2) or § 154.706(b);

(2) Loss of the ventilation under § 154.706(a)(2) or § 154.707(c); or

(3) Loss of inert gas pressure within the double-walled piping system under § 154.706(a)(1).

§ 154.709 Cargo boil-off as fuel: gas detection equipment.

(a) The continuous gas detection system required under § 154.706(a)(2) and (b) must—

(1) Meet § 154.1350(c), (d), and (j) through (s); and

(2) Have a device that—

(i) Activates an audible and visual alarm at the machinery control station and in the wheelhouse if the methane concentration reaches 1.5 percent by volume; and

(ii) Closes the master gas fuel valve required under § 154.708(c) before the methane concentration reaches 3 percent by volume.

(b) The number and arrangement of gas sampling points must be specially approved by the Commandant (G–MMT).

Cargo Vent Systems

§ 154.801 Pressure relief systems.

(a) Each cargo tank that has a volume of 20m³ (706 ft.³) or less must have at least one pressure relief valve.

(b) Each cargo tank that has a volume of more than 20m³ (706 ft.³) must have at least two pressure relief valves of the same nominal relieving capacity.

(c) Each pressure relief valve must—

(1) Meet Subpart 162.018 of this chapter or, if the valve is also capable of vacuum relief and the MARVS is 69 kPa gauge (10 psig) or less, Subpart 162.017 of this chapter, and have at least the capacity required under § 154.806;

(2) Not be set for a higher pressure than the MARVS;

(3) Have a fitting for sealing wire that prevents the set relieving pressure from being changed without breaking the sealing wire;

(4) Be fitted on the cargo tank to remain in the vapor phase under conditions of 15° list and of 0.015 L trim by both the bow and stern;

(5) Vent to a vent mast under § 154.805, except a relief valve may vent to a common tank relief valve header if the back pressure is included in determining the required capacity under § 154.806;

(6) Not vent to a common header or common vent mast if the relief valves are connected to cargo tanks carrying chemically incompatible cargoes;

(7) Not have any stop valves or other means of isolating the cargo tank from its relief valve unless—

(i) The stop valves are interlocked or arranged so that only one pressure relief valve is out of service at any one time;

(ii) The interlock arrangement automatically shows the relief valve that is out of service; and

(iii) The other valves have the relieving capacity required under § 154.806, or all relief valves on the cargo tank are the same size and there is a spare of the same size, or there is a spare for each relief valve on a cargo tank.

(d) The pressure relief system must—

(i) If the design temperature is below 0° C (32° F), be designed to prevent the relief valve from becoming inoperative due to ice formation; and

(ii) Be designed to prevent chattering of the relief valve.

§ 154.802 Alternate pressure relief settings.

Cargo tanks with more than one relief valve setting must have one of the following arrangements:

(a) Relief valves that—

(1) Are set and sealed under § 154.801(c);

(2) Have the capacity under § 154.806; and

(3) Are interlocked so that cargo tank venting can occur at any time.

(b) Relief valves that have spacer pieces or springs that—

(1) Change the set pressure without pressure testing to verify the new setting; and

(2) Can be installed without breaking the sealing wire required under § 154.801(c)(3).

§ 154.804 Vacuum protection.

(a) Except as allowe d under paragraph (b) of this section, each cargo tank must have a vacuum protection system meeting paragraph (a)(1) of this section and either paragraph (a)(2) or (a)(3) of this section.

(1) There must be a means of testing the operation of the system.

(2) There must be a pressure switch that operates an audible and visual alarm in the cargo control station identifying the tank and the alarm condition and a remote group audible and visual alarm in the wheelhouse. Both alarms must be set at or below 80% of the maximum external design pressure differential of the cargo tanks. There must be a second, independent pressure switch that automatically shuts off all suction of cargo liquid or vapor from the cargo tank and secures any refrigeration of that tank at or below the maximum external designed pressure differential.

(3) There must be a vacuum relief valve that—

(i) Has a gas flow capacity at least equal to the maximum cargo discharge rate per tank;

(ii) Is set to open at or below the maximum external designed pressure differential; and

(iii) Admits inert gas, cargo vapor from a source other than a cargo vapor header, or air except as prohibited under § 154.1710.

(b) A vacuum protection system does not have to be installed if the cargo tank is designed to withstand—

(1) A maximum external pressure differential exceeding 24.5 kPa gauge (3.55 psig); and

(2) The maximum external pressure differential that can be obtained—

(i) At maximum discharge rates with no vapor return to the cargo tanks;

(ii) By operation of the cargo refrigeration system; or

(iii) By drawing off vapor for use in accordance with § 154.703(c)

§ 154.805 Vent masts.

Relief valves or common vent headers from relief valves must discharge to a vent mast that—

(a) Discharges vertically upward;

(b) Has a rain cap or other means of preventing the entrance of rain or snow;

(c) Has a screen with 25mm (1 inch) wire mesh or bars not more than 25mm (1 in.) apart on the discharge port;

(d) Extends at least to a height of B/3 or 6m (19.7 ft.), whichever is greater, above the weather deck and 6m (19.7 ft.) above the working level;

(e) For a cargo tank, does not exhaust cargo vapors within a radius of B or 25m (82 ft.), whichever is less, from any forced or natural ventilation intake or other opening to an accommodation, service, control station, or other gas-safe space, except that for vessels less than 90m (295 ft.) in length, shorter distances may be specially approved by the Commandant (G-MMT);

(f) For a containment system, except a cargo tank, does not exhaust vapor within a radius of 10m (32.8 ft.) or less from any forced or natural ventilation intake or other opening to an accommodation, service, control station, or other gas-safe space;

(g) Has drains to remove any liquid that may accumulate; and

(h) Prevents accumulations of liquid at the relief valves.

§ 154.806 Capacity of pressure relief valves.

Pressure relief valves for each cargo tank must have a combined relief capacity, including the effects of back pressure from vent piping, headers, and masts, to discharge the greater of the following with not more than a 20% rise in cargo tank pressure above the set pressure of the relief valves:

(a) The maximum capacity of an installed cargo tank inerting system if the maximum attainable working pressure of the cargo tank inerting system exceeds the set pressure of the relief valves.

(b) The quantity of vapors generated from fire exposure that is calculated under § 54.15-25 of this chapter.

Atmospheric Control in Cargo Containment Systems

§ 154.901 Atmospheric control within cargo tanks and cargo piping systems.

(a) Each vessel must have a piping system for purging each cargo tank and all cargo piping.

(b) The piping system must minimize the pocketing of gas or air remaining after purging.

(c) For cargo tanks certificated to carry flammable gases, the piping system must allow purging the tank of flammable vapors before air is introduced and purging the tank of air before the tank is filled with cargo.

(d) Each cargo tank must have—

(1) Gas sampling points at its top and bottom; and

(2) Gas sampling line connections that are valved and capped above the deck.

§ 154.902 Atmospheric control within hold and interbarrier spaces.

(a) Vessels certificated to carry flammable cargo in cargo containment systems with full secondary barriers must have an inert gas system or onboard storage of inert gas that provides enough inert gas to meet the requirements of § 154.1848 for 30 days consumption.

(b) Vessels certificated to carry flammable cargo in cargo containment systems with partial secondary barriers must—

(1) Have an inert gas system or onboard inert gas storage that can inert the largest hold and interbarrier space so that the oxygen concentration is 8 percent or less by volume; and

(2) Meet paragraph (a) or (c)(2) of this section.

(c) Vessels certificated to carry only nonflammable cargo in cargo containment systems with secondary barriers must—

(1) Meet paragraph (a) of this section; or

(2) Have air drying systems that reduce the dewpoint of air admitted to hold or interbarrier spaces below the temperature of any surface in those spaces or −45° C (−49° F), whichever is warmer.

(d) Vessels with refrigerated independent tanks type C must have inert gas or air drying systems that reduce the dewpoint of any inert gas or air admitted to the hold spaces below the temperature of any surface in those spaces or −45° C (−49° F), whichever is warmer.

§ 154.903 Inert gas systems: general.

(a) Inert gas carried or generated to meet §§ 154.901, 154.902, and 154.1848 must be non-flammable and non-reactive with the cargoes that the vessel is certificated to carry and the materials of construction of the cargo tanks, hold and interbarrier spaces, and insulation.

(b) The boiling point and dewpoint at atmospheric pressure of the inert gas must be below the temperature of any surface in those spaces or −45° C (−49° F), whichever is warmer.

(c) For the temperatures and pressures at which the gas is stored and used, storage vessels and inert gas piping must meet §§ 154.450 and 154.500 respectively.

§ 154.904 Inert gas system: controls.

The inert gas system must have—

(a) At least one check valve in the cargo area to prevent the back flow of cargo vapor into the inert gas system, or another means specially approved by the Commandant (G–MMT);

(b) If the inert gas system is in the machinery space or another space outside the cargo area, a second check valve in the cargo area meeting paragraph (a) of this section;

(c) Automatic and manual inert gas pressure controls; and

(d) Valves to isolate each inerted space.

§ 154.906 Inert gas generators.

The inert gas generator must—

(a) Produce an inert gas containing less than 5% oxygen by volume;

(b) Have a device to continuously sample the discharge of the generator for oxygen content; and

(c) Have an audible and visual alarm in the cargo control station that alarms when the inert gas contains 5% or more oxygen by volume.

§ 154.908 Inert gas generator: location.

(a) Except as allowed in paragraph (b) of this section, an inert gas generator must be located in the main machinery space or a space that is not in the cargo area and does not have direct access to any accommodation, service, or control space.

(b) An inert gas generator that does not use flame burning equipment may be located in the cargo area if specially approved by the Commandant (G–MMT).

§ 154.910 Inert gas piping: location.

Inert gas piping must not pass through or terminate in an accommodation, service, or control space.

§ 154.912 Inerted spaces: relief devices.

Inerted spaces must be fitted with relief valves, rupture discs, or other devices specially approved by the Commandant (G–MMT).

Electrical

§ 154.1000 Applicability.

Sections 154.1005 through 154.1020 apply to flammable cargo and ammonia carriers.

§ 154.1002 Definition.

For the purposes of §§ 154.1005 through 154.1020, "gas-dangerous" does not include the weather deck of an ammonia carrier.

§ 154.1005 Equipment approval.

(a) Electrical equipment that is required to be intrinsically safe or explosion proof under § 154.1010 must be specially approved by the Commandant or listed as intrinsically safe or explosion proof by an independent laboratory that is specially approved by the Commandant (G–MMT), for Class I Division I locations and the Group that is specified in Table 4 for the cargo carried.

(b) Each submerged cargo pump motor installation must be specially approved by the Commandant (G–MMT).

(c) Electrical equipment that must be intrinsically safe to meet § 154.1010 must meet the definition in § 110.15–100(i) of this chapter.

(d) Electrical equipment that must be explosion proof to meet § 154.1010 must meet § 110.15–65(e) of this chapter.

§ 154.1010 Electrical equipment in gas-dangerous space or zone.

(a) Except as allowed in this section, electrical equipment must not be installed in a gas-dangerous space or zone.

(b) Intrinsically safe electrical equipment and wiring may be in a gas-dangerous space or zone.

(c) A submerged cargo pump motor may be in a cargo tank if—

(1) Low liquid level, motor current, or pump discharge pressure automatically shuts down power to the pump motor if the pump loses suction;

(2) There is an audible and visual alarm at the cargo control station that actuates if the motor shuts down under the requirements of paragraph (c)(1) of this section; and

(3) There is a lockable circuit breaker or lockable switch that disconnects the power to the motor.

(d) A supply cable for a submerged cargo pump motor may be in a hold space.

(e) A hold space that has a tank that is not required to have a secondary barrier under § 154.459 may only have—

(1) Through runs of cable;

(2) Explosion-proof lighting fixtures;

(3) Depth sounding devices in gas-tight enclosures;

(4) Log devices in gas-tight enclosures; and

(5) Impressed current cathodic protection system electrodes in gas-tight enclosures.

(f) A space that is separated by a gastight steel boundary from a hold space that has a cargo tank that must have a secondary barrier, under the requirements of § 154.459, may only have—

(1) Through runs of cable;

(2) Explosion-proof lighting fixtures;

(3) Depth sounding devices in gastight enclosures;

(4) Log devices in gastight enclosures;

(5) Impressed current cathodic protection system electrodes in gastight enclosures;

(6) Explosion-proof motors that operate cargo system valves or ballast system valves; and

(7) Explosion-proof bells for general alarm systems.

(g) A cargo handling room may only have—

(1) Explosion-proof lighting fixtures; and

(2) Explosion-proof bells for general alarm systems.

(h) A space for cargo hose storage may only have—

(1) Explosion-proof lighting fixtures; and

(2) Through runs of cable.

(i) A space that has cargo piping may only have—

(1) Explosion-proof lighting fixtures; and

(2) Through runs of cable.

(j) A gas-dangerous zone on the weather deck may only have—

(1) Explosion-proof equipment that is for the operation of the vessel; and

(2) Through runs of cable.

(k) A space, except those under paragraphs (e) through (j) of this section, that has a direct opening to a gas-dangerous space or zone may only have the electrical equipment allowed in the gas-dangerous space or zone.

§ 154.1015 Lighting in gas-dangerous space.

(a) Each gas-dangerous space that has lighting fixtures must have at least two branch circuits for lighting.

(b) Each switch and each overcurrent protective device for any lighting circuit that is in a gas-dangerous space must open each conductor of the circuit simultaneously.

(c) Each switch and each overcurrent protective device for lighting in a gas-dangerous space must be in a gas-safe space.

§ 154.1020 Emergency power.

The emergency generator must be designed to allow operation at the final angle of heel under § 154.230(a).

Firefighting

Firefighting System: Exterior Water Spray

§ 154.1105 Exterior water spray system: General.

Each liquefied flammable gas vessel and each liquefied toxic gas vessel must have an exterior water spray system that meets §§ 154.1110 through 154.1135.

§ 154.1110 Areas protected by system.

Each water spray system must protect—

(a) All cargo tank surfaces that are not covered by the vessel's hull structure or a steel cover;

9(b) Each cargo tank dome;

(c) Each on-deck storage vessel for flammable or toxic liquefied gases;

(d) Each cargo discharge and loading manifold;

(e) Each quick-closing valve under §§ 154.530, 154.532, and 154.538, and other control valves essential to cargo flow;

(f) Each boundary facing the cargo area of each superstructure that contains accommodation, service, or control spaces;

(g) Each boundary facing the cargo area of each deckhouse that contains accommodation, service, or control spaces; and

(h) Each boundary of each deckhouse that is within the cargo area and that is manned during navigation of the vessel or during cargo transfer operations, except the deckhouse roof if it is 2.4 m (7.9 ft.) or higher above the cargo containing structure.

§ 154.1115 Discharge.

(a) The discharge density of each water spray system must be at least—

(1) 10000 $cm^3/m^2/min.$ (0.25 $gpm/ft.^2$) over each horizontal surface; and

(2) 4000 $cm^3/m^2/min.$ (0.10 $gpm/ft.^2$) against vertical surface, including the water rundown.

(b) The water spray protection under § 154.1110 (d) and (e) must cover an area in a horizontal plane extending at least 0.5 m (19 in.) in each direction from the pipes, fittings, and valves, or the area of the drip tray, whichever is greater.

§ 154.1120 Nozzles.

(a) Nozzles for the water spray system must be spaced to provide the minimum discharge density under § 154.1115 in each part of the protected area.

(b) The vertical distance between water spray nozzles for the protection of vertical surfaces must be 3.7 m (12 ft.) or less.

§ 154.1125 Pipes, fittings, and valves.

(a) Each pipe, fitting, and valve for each water spray system must meet part 56 of this chapter.

(b) Each water spray main that protects more than one area listed in § 154.1110 must have at least one isolation valve at each branch connection and at least one isolation valve downstream of each branch connection to isolate damaged sections.

(c) Each valved cross-connection from the water spray system to the fire main must be outside of the cargo area.

(d) Each pipe, fitting, and valve for the water spray system must be made of fire resistant and corrosion resistant materials, such as galvanized steel or galvanized iron pipe.

(e) Each water spray system must have a means of drainage to prevent corrosion of the system and freezing of accumulated water in subfreezing temperatures.

(f) Each water spray system must have a dirt strainer that is located at the water spray system manifold or pump.

§ 154.1130 Sections.

(a) If a water spray system is divided into sections, each section must at least include the entire deck area bounded by the length of a cargo tank and the full beam of the vessel.

(b) If a water spray system is divided into sections, the control valves must be at a single manifold that is aft of the cargo area.

§ 154.1135 Pumps.

(a) Water to the water spray system must be supplied by—

(1) A pump that is only for the use of the system;

(2) A fire pump; or

(3) A pump specially approved by the Commandant (G–MMT).

(b) Operation of a water spray system must not interfere with simultaneous operation of the fire main system at its required capacity. There must be a valved cross-connection between the two systems.

(c) Except as allowed under pararaph (d) of this section, each pump for each water spray system must have the capacity to simultaneously supply all areas named in § 154.1110.

(d) If the water spray system is divided into sections, the pump under paragraph (a) of this section must have the capacity to simultaneously supply the required discharge density under § 154.1115(a) for—

(1) The areas in §§ 154.1110(f) through (h) and 154.1115(b); and

(2) The largest section that includes the required protection under § 154.1110 (a), (b), and (c).

Firefighting System: Dry Chemical

§ 154.1140 Dry chemical system: General.

Each liquefied flammable gas carrier must have a dry chemical firefighting system that meets §§ 154.1145 through 154.1170, Part 56 and Subpart 162.039 of this chapter.

§ 154.1145 Dry chemical supply.

(a) A vessel with a cargo carrying capacity less that 1000 m^3 (35,300 $ft.^3$) must have at least one self-contained dry chemical storage unit for the cargo area with an independent inert gas pressurizing source adjacent to each unit.

(b) A vessel with a cargo carrying capacity of 1000 m^3 (35,300 $ft.^3$) or more must have at least two self-contained dry chemical storage units for the cargo area with an independent inert gas pressurizing source adjacent to each unit.

(c) A vessel with bow and stern loading and discharge areas must have at least one self-contained dry chemical storage unit with an independent inert gas pressurizing source adjacent to the unit for each area.

(d) Each dry chemical storage unit and associated piping must be designed for—

(1) Sequential discharge of each hose line and each monitor for 45 seconds; and

(2) Simultaneous discharge of all hose lines and monitors for 45 seconds.

(e) Each fully charged dry chemical storage unit must have the greater of the following:

(1) Enough dry chemical to provide for sequential discharge of each attached hose and monitor for 45 seconds.

(2) Enough dry chemical to provide for simultaneous discharge of all attached hoses and monitors for 45 seconds.

§ 154.1150 Distribution of dry chemical.

(a) All locations on the above deck cargo area and the cargo piping outside that cargo area must be protected by—

(1) At least two dry chemical hand hose lines; or

(2) At least one dry chemical hand hose line and one dry chemical monitor.

(b) At least one dry chemical storage unit and hand hose line or monitor must be at the after end of the cargo areas.

(c) Each cargo loading and discharge manifold must be protected by at least one dry chemical monitor.

§ 154.1155 Hand hose line coverage.

The coverage for the area for a hand hose line under § 154.1150 must not exceed the length of the hand hose line except the coverage for the protection of areas that are inaccessible to personnel must not exceed one-half the projection of the hose at its rated discharge, or 10 m (32.8 ft.), whichever is less.

§ 154.1160 Monitor coverage of system.

The coverage of each dry chemical system monitor under § 154.1150 must not exceed—

(a) 10 m (32.8 ft.) at 10 kg/sec (22 lb/sec);

(b) 30 m (98.4 ft.) at 25 kg/sec (55 lb/sec);

(c) 40 m (131.2 ft.) at 45 kg/sec (99 lb/sec);

(d) An interpolation between 10 m (32.8 ft.) at 10 kg/sec (22 lb/sec) and 30 m (98.4 ft.) at 25 kg/sec (55 lb/sec); or

(e) An interpolation between 30 m (98.4 ft.) at 25 kg/sec (55 lb/sec) and 40 m (131.2 ft.) at 45 kg/sec (99 lb/sec).

§ 154.1165 Controls.

(a) Each dry chemical hand hose line must be one that can be actuated at its hose reel or hose storage cabinet.

(b) Each dry chemical monitor must be one that can be actuated and controlled at the monitor.

(c) A dry chemical monitor for the cargo loading and discharging manifold areas must be one that can be—

(1) Actuated from a location other than the monitor and manifold area; and

(2) Except for pre-aimed monitors, controlled from a location other than the monitor and manifold area.

(d) Each dry chemical storage unit must have independent piping with a stop valve in the piping for each remote hand hose line and remote monitor where the piping connects to the storage container, if the unit has—

(1) More than one hand hose line;

(2) More than one monitor; or

(3) A combination of hand hose lines and monitors.

(e) Each stop valve under paragraph (d) of the section must be capable of—

(1) Manual operation; and

(2) Being opened from the hose reel or monitor to which it is connected.

(f) Damage to any dry chemical system hose, monitor, pipe or control circuits must not prevent the operation of other hoses, monitors, or control circuit that are connected to the same storage unit.

§ 154.1170 Hand hose line: General.

Each dry chemical hand hose line must—

(a) Not be longer than 33m (108 ft.);

(b) Be stored on a hose reel or in a hose cabinet and be one that is operable whether or not it is unwound from a hose reel or removed from a hose cabinet;

(c) Be non-kinkable;

(d) Have a nozzle with a valve to start and stop the flow of chemical;

(e) Have a capacity of at least 3.5 kg/sec (7.7 lb./sec); and

(f) Be one that can be operated by one person.

Cargo Area: Mechanical Ventilation System

§ 154.1200 Mechanical ventilation system: General.

(a) Each cargo compressor room, pump room, gas-dangerous cargo control station, and space that contains cargo handling equipment must have a fixed, exhaust-type mechanical ventilation system.

(b) The following must have a supply-type mechanical ventilation system:

(1) Each space that contains electric motors for cargo handling equipment.

(2) Each gas-safe cargo control station in the cargo area.

(3) Each gas-safe space in the cargo area.

(4) Each space that contains inert gas generators, except main machinery spaces.

§ 154.1205 Mechanical ventilation system: Standards.

(a) Each exhaust type mechanical ventilation system required under § 154.1200 (a) must have ducts for vapors from the following:

(1) The deck level.

(2) Bilges.

(3) If the vapors are lighter than air, the top of each space that personnel enter during cargo handling operations.

(b) The discharge end of each duct under paragraph (a) of this section must be at least 10 m (32.8 ft.) from ventilation intakes and openings to accomodation, service, control station, and other gas-safe spaces.

(c) Each ventilation system under §§ 154.1200(a) and (b)(1) must change the air in that space and its adjoining trunks at least 30 times each hour.

(d) Each ventilation system for a gas-safe cargo control station in the cargo area must change the air in that space at least eight times each hour.

(e) A ventilation system must not recycle vapor from ventilation discharges.

(f) Each mechanical ventilation system must have its operational controls outside the ventilated space.

(g) No ventilation duct for a gas-dangerous space may pass through any machinery, accomodation, service, or control space, except as allowed under § 154.703.

(h) Each electric motor that drives a ventilation fan must not be within the ducts for any space that may contain flammable cargo vapors.

(i) Ventilation impellers and the housing in way of those impellers on a flammable cargo carrier must meet one of the following:

(1) The impeller, housing, or both made of non-metallic material that does not generate static electricity.

(2) The impeller and housing made of non-ferrous material.

(3) The impeller and housing made of austenitic stainless steel.

(4) The impeller and housing made of ferrous material with at least 13mm (0.512 in.) tip clearance.

(j) No ventilation fan may have any combination of fixed or rotating components made of an aluminum or magnesium alloy and ferrous fixed or rotating components.

(k) Each ventilation intake and exhaust must have a protective metal screen of not more than 13mm (0.512 in.) square mesh.

§ 154.1210 Hold space, void space, cofferdam, and spaces containing cargo piping.

(a) Each hold space, void space, cofferdam, and spaces containing cargo piping must have—

(1) A fixed mechanical ventilation system; or

(2) A fixed ducting system that has a portable blower that meets § 154.1205(i) and (j).

(b) A portable blower in any personnel access opening must not reduce the area of that opening so that the opening does not meet § 154.340.

Instrumentation

§ 154.1300 Liquid level gauging system: General.

(a) If Table 4 lists a closed gauge for a cargo, the liquid level gauging system under § 154.1305 must be closed gauges that do not have any opening through which cargo liquid or vapor could escape, such as an ultrasonic device, float type device, electronic or magnetic probe, or bubble tube indicator.

(b) If Table 4 lists a restricted gauge for a cargo, the liquid level gauging system under § 154.1305 must be closed gauges that meet paragraph (a) of this section or restricted gauges that do not vent the cargo tank's vapor space, such as a fixed tube, slip tube, or rotary tube.

§ 154.1305 Liquid level gauging system: Standards.

(a) Each cargo tank must have at least one liquid level gauging system that is operable—

(1) At pressure up to, and including, the MARVS of the tank; and

(2) At temperatures that are within the cargo handling temperature range for all cargoes carried.

(b) Unless the cargo tank has one liquid gauging system that can be repaired and maintained when the tank contains cargo, each cargo tank must have at least two liquid level gauging systems that meet paragraph (a) of this section.

(c) Each liquid level gauging system must measure liquid levels from 400 mm (16 in.) or less from the lowest point in the cargo tank, except collection wells, to 100 percent full.

§ 154.1310 Closed gauge shut-off valve.

Each closed gauge that is not mounted directly on the cargo tank must have a shut-off valve that is as close to the tank as practical.

§ 154.1315 Restricted gauge excess flow valve.

Each restricted gauge that penetrates a cargo tank must have an excess flow valve unless the gauge meets § 154.536.

§ 154.1320 Sighting ports, tubular gauge glasses, and flat plate type gauge glasses.

(a) Cargo tanks may have sighting ports as a secondary means of liquid level gauging in addition to the gauges under § 154.1305, if—

(1) The tank has a MARVS that is less than 69 kPa gauge (10 psig);

(2) The port has a protective cover and an internal scale; and

(3) The port is above the liquid level.

(b) Tubular gauge glasses must not be liquid level gauges for cargo tanks.

(c) Plate type gauge glasses must not be liquid level gauges for cargo tanks, except deck tanks if the gauge connections have excess flow valves.

§ 154.1325 Liquid level alarm system: All cargo tanks.

Except as allowed under § 154.1330, each cargo tank must have a high liquid level alarm system that—

(a) Is independent of the liquid level gauging system under § 154.1305;

(b) Actuates quick-closing valves under §§ 154.530, 154.532, and 154.538 or a stop valve in the cargo tank loading line to prevent the tank from becoming 100 percent liquid full and without causing the pressure in the loading lines to exceed the design pressure; and

(c) Actuates an audible and visual alarm at the cargo control station at the liquid level at which the valves under paragraph (b) of this section are actuated or at some lower liquid level.

§ 154.1330 Liquid level alarm system: Independent tank type C.

Independent tanks type C need not have the high liquid level alarm system under § 154.1325 if—

(a) The tank volume is less than 200 m^3 (7,060 $ft.^3$); or

(b) The tank can withstand the maximum possible pressure during loading, that pressure is below the relief valve setting, and overflow of the tank cannot occur.

§ 154.1335 Pressure and vacuum protection.

(a) Each cargo tank must have the following:

(1) A pressure gauge that—

(i) Monitors the vapor space;

(ii) Is readable at the tank; and

(iii) Has remote readouts at the cargo control station.

(2) If vacuum protection is required under § 154.804, a vacuum gauge meeting paragraphs (a)(1)(i), (a)(1)(ii), and (a)(1)(iii) of this section.

(b) The vessel must have at least one high pressure alarm that—

(1) Actuates before the pressure in any cargo tank exceeds the maximum pressure specially approved by the Commandant (G–MMT); and

(2) Actuates an audible and visual alarm at the cargo control station, and a remote group alarm in the wheelhouse.

(c) If vacuum protection is required under § 154.804, the vessel must have at least one low pressure alarm that—

(1) Actuates before the pressure in any cargo tank falls below the minimum pressure specially approved by the Commandant (G–MMT); and

(2) Actuates an audible and visual alarm at the cargo control station, and a remote group alarm in the wheelhouse.

(d) At least one pressure gauge must be fitted on each—

(1) Enclosed hold;

(2) Enclosed interbarrier space;

(3) Cargo pump discharge line;

(4) Liquid cargo manifold; and

(5) Vapor cargo manifold.

(e) There must be a local manifold pressure gauge between each manifold stop valve and each hose connection to the shore.

§ 154.1340 Temperature measuring devices.

(a) Each cargo tank must have devices that measure the temperature—

(1) At the bottom of the tank; and

(2) Near the top of the tank and below the maximum liquid level allowed under § 154.1844.

(b) Each device required by paragraph (a) must have a readout at the cargo control station.

(c) Except for independent tanks type C, each cargo containment system for a design temperature colder than −55° C (−67° F) must have temperature measuring devices that meet the following:

(1) The number and location of the devices must be specially approved by the Commandant(G–MMT).

(2) The devices must be within the cargo tank's insulation or on the adjacent hull structure.

(3) Each device must show the temperature continuously or at regular intervals of one hour or less.

(4) Each device must actuate an audible and visual alarm at the cargo control station and a remote group alarm in the wheelhouse before the temperature of the steel of the adjacent hull structure is cooled below the lowest temperature allowed for the steel under § 154.172.

(d) For each cargo tank with a design temperature colder than −55° C (−67° F), the number and arrangement of the devices that show the temperature of the tank during cool down procedures must be specially approved by the Commandant (G–MMT).

§ 154.1345 Gas detection.

(a) Each vessel carrying a cargo that is designated with an "I" or "I and T" in Table 4 must have—

(1) A fixed flammable gas detection system that meets § 154.1350; and

(2) Two portable gas detectors that can each measure 0 to 100% of the lower flammable limit of the cargo carried.

(b) Each vessel carrying a cargo that is designated with a "T" or "I and T" in Table 4 must have—

(1) Two portable gas detectors that show if the concentration of cargo is above or below the threshold limit value listed in 29 CFR 1910.1000 for that cargo; and

(2) Fixed gas sampling tubes in each hold space and interbarrier space with—

(i) The number of tubes specially approved by the Commandant (G-MMT);

(ii) Each tube valved and capped above the main deck unless it is connected to a fixed toxic gas detector;

(iii) If the vessel carries cargo that is heavier than the atmosphere of the space, each tube's open end in the lower part of the space;

(iv) If the vessel carries cargo that is lighter than the atmosphere of the space, each tube's open end in the upper part of the space;

(v) If the vessel carries cargo that is heavier than the atmosphere of the space and another cargo that is lighter than the atmosphere of the space, tubes with their open ends in the lower part of the space and tubes with their open ends in the upper part of the space; and

(vi) If the vessel carries cargo that can be both heavier and lighter than the atmosphere of the space, tubes with their open ends in the lower part of the space and tubes with their open ends in the upper part of the space.

(c) A vessel that carries methyl bromide or sulfur dioxide must have a fixed gas detection system that is not located in a gas-safe space.

(d) A vessel that carries sulfur dioxide must have a fixed gas detection system that meets § 154.1350 except paragraph (j).

(e) Each alarm under § 154.1350(e) on a vessel that carries methyl bromide or sulfur dioxide must be set at or below the threshold limit value listed in 29 CFR 1910.1000 for the cargo carried.

§ 154.1350 Flammable gas detection system.

(a) The vessel must have a fixed flammable gas detection system that has sampling points in—

(1) Each cargo pump room;

(2) Each cargo compressor room;

(3) Each motor room for cargo handling machinery;

(4) Each cargo control station that is not gas-safe;

(5) Each hold space, interbarrier space, and other enclosed spaces, except fuel oil or ballast tanks, in the cargo area, unless the vessel has independent tanks type C; and

(6) Each space between the doors of an air lock under § 154.345.

(b) The sampling points under paragraph (a) of this section must meet § 154.1345(b)(2) (iii) through (vi).

(c) Gas sampling lines for the flammable gas detection system must not pass through any gas-safe space, except the gas-safe space in which the gas detection equipment is located.

(d) Gas detection systems must have a readout with meters that show flammable gas concentration over the concentration or volume ranges under paragraph (t) or (u) of this section.

(e) Each flammable gas detection system must have audible and visual alarms that are actuated at a cargo concentration that is 30% or less of the lower flammable limit in air of the cargo carried.

(f) Each flammable gas detection system must have an audible and visual alarm for power failure and loss of gas sampling flow.

(g) The alarms under paragraphs (e) and (f) of this section must signal in the space where the gas detection system's readout is located and must meet § 154.1365.

(h) Remote group alarms, that indicate that one of the alarm conditions under paragraphs (e) and (f) of this section exists, must meet § 154.1365 and must be in each wheelhouse and in each cargo control station if the gas detection system's readout is not located in those spaces.

(i) Each flammable gas detection system must monitor each sampling point at 30 minute or shorter intervals.

(j) Electrical equipment for each flammable gas detection system that is in a gas-dangerous space or area must meet §§ 154.1000 through 154.1015.

(k) Each flammable gas detection system must have enough flame arrestors for all gas sampling lines to prevent flame propagation to the spaces served by the system through the sampling lines.

(l) Each flammable gas detection system must have a filter that removes particulate matter in each gas sampling line.

(m) Each filter under paragraph (l) of this section must be located where it can be removed during vessel operation, unless it can be freed by back pressure.

(n) Each flammable gas detection system in a gas-safe space must—

(1) Have a shut-off valve in each sampling line from an enclosed space, such as a hold or interbarrier space; and

(2) Exhaust gas to a safe location in the open atmosphere and away from all ignition sources.

(o) Each flammable gas detection system must not have common sampling lines, except sampling lines may be manifolded at the gas detector location if each line has an automatic valve that prevents cross-communication between sampling points.

(p) Each flammable gas detection system must have at least one connection for injecting zero gas and span gas into the system for testing and calibration.

(q) Each flammable gas detection system must have span gas for testing and calibration that is of known concentration.

(r) The calibration test procedure and type and concentration of span gas under paragraph (q) of this section must be on or in each gas analyzer cabinet.

(s) Each flammable gas detection system must have at least one flow meter capable of measuring the flow to the gas analyzer, and must provide a means for ensuring that there is a positive flow in the right direction in each sampling line at all times.

(t) Each flammable gas detection system must measure gas concentrations that—

(1) Are at least 0% through 200% of the alarm concentration; and

(2) Allow calibration of the equipment with span gas.

(u) In each hold and each interbarrier space that contains tanks other than independent tanks type A, B, or C, the flammable gas detection system must measure cargo concentrations of 0 to 100% by volume with—

(1) An analyzer other than the one under paragraph (t) of this section; or

(2) The analyzer under paragraph (t) of this section with a scale switch that automatically returns the analyzer to the concentration range under paragraph (t) of this section when released.

§ 154.1360 Oxygen analyzer.

The vessel must have a portable analyzer that measures oxygen levels in an inert atmosphere.

§ 154.1365 Audible and visual alarms.

(a) Each audible alarm must have an arrangement that allows it to be turned off after sounding. For remote group alarms this arrangement must not interrupt the alarm's actuation by other faults.

(b) Each visual alarm must be one that can be turned off only after the fault that actuated it is corrected.

(c) Each visual alarm must be marked to show the type and, except for remote group alarms, the location of each fault that actuates it.

(d) Each vessel must have means for testing each alarm.

§ 154.1370 Pressure gauge and vacuum gauge marking.

Each pressure gauge and vacuum gauge under § 154.1335(a) must be marked with the maximum and minimum pressures that are specified on the vessel's certificate for the cargo carried.

§ 154.1375 Readout for temperature measuring device: Marking.

Each readout under § 154.1340 for a device that measures temperature in a cargo tank must be marked with the design temperature specified for the cargo tank on the vessel's certificate.

Safety Equipment

§ 154.1400 Safety equipment: All vessels.

(a) Instead of the equipment under § 35.30–20 of this chapter, a vessel of less than 25,000 m^3 cargo capacity must have the following personnel safety equipment:

(1) Six self-contained, pressure-demand-type, air-breathing apparatus approved by the Mining Enforcement and Safety Administration (MESA) or the National Institute for Occupational Safety and Health (NIOSH), each having at least a 30 minute capacity.

(2) Nine spare bottles of air for the self-contained air-breathing apparatus, each having at least a 30 minute capacity.

(3) Six steel-cored lifelines.

(4) Six three-cell, explosion proof flashlights with the Underwriters' Laboratories, Inc., label for Class I Division 1 and the Electrical Hazard Group listed in Table 4 for each cargo carried.

(5) Three fire axes.

(6) Six helmets that meet ANSI Safety Requirements for Industrial Head Protection, Z–89.1 (1969).

(7) Six sets of boots and gloves that are made of rubber or other electrically non-conductive material.

(8) Six sets of goggles that meet the specifications of ANSI Practice for Occupational and Educational Eye and Face Protection, Z–87.1 (1968).

(9) Three outfits that protect the skin from scalding steam and the heat of a fire, and that have a water resistant outer surface.

(10) Three chemical protective outfits that protect the wearers from the particular personnel hazards presented by the cargo vapor.

(b) Instead of the equipment under § 35.30–20 of this chapter, a vessel of 25,000 m^3 cargo capacity or more must have the following personnel safety equipment:

(1) Eight self-contained, pressure-demand-type, air-breathing apparatus approved by the Mining Enforcement and Safety Administration (MESA) or the National Institute for Occupational Safety and Health (NIOSH), each having at least a 30 minute capacity.

(2) Nine spare bottles of air for the self-contained air-breathing apparatus, each having at least a 30 minute capacity.

(3) Eight steel-cored lifelines.

(4) Eight three-cell, explosion proof flashlights with the Underwriters' Laboratories, Inc., label for Class I Division 1 and the Electrical Hazard Group listed in Table 4 for each cargo carried.

(5) Five fire axes.

(6) Eight helmets that meet ANSI Safety Requirements for Industrial Head Protection, Z–89.1 (1969).

(7) Eight sets of boots and gloves that are made of rubber or other electrically non-conductive material.

(8) Eight sets of goggles that meet the specifications of ANSI Practice for Occupational and Educational Eye and Face Protection, Z–87.1 (1968).

(9) Five outfits that protect the skin from scalding steam and the heat of a fire, and that have a water resistant outer surface.

(10) Three chemical protective outfits that protect the wearers from the particular personnel hazards presented by the cargo vapor.

(c) When Table 4 references this section, a vessel carrying the listed cargo must have the following additional personnel protection equipment:

(1) Three self-contained, pressure-demand-type, air-breathing apparatus approved by the Mining Enforcement and Safety Administration (MESA) or the National Institute for Occupational Safety and Health (NIOSH), each having at least a 30 minute capacity.

(2) Nine spare bottles of air for the self-contained air-breathing apparatus, each having at least a 30 minute capacity.

(3) Three steel-cored lifelines.

(4) Three three-cell, explosion proof flashlights with the Underwriters' Laboratories, Inc., label for Class I Division 1 and the Electrical Hazard Group listed in Table 4 for each cargo carried.

(5) Three helmets that meet ANSI Safety Requirements for Industrial Head Protection, Z–89.1 (1969).

(6) Three sets of boots and gloves that are made of rubber or other electrically non-conductive material.

(7) Three sets of goggles that meet the specifications of ANSI Practice for Occupational and Educational Eye and Face Protection, Z–87.1 (1968).

(8) Three chemical protective outfits that protect the wearers from the particular personnel hazards presented by the cargo vapor.

§ 154.1405 Respiratory protection.

When Table 4 references this section, a vessel carrying the listed cargo must have—

(a) Respiratory protection equipment for each person on board that protects the person from the cargo vapor for at least 5 minutes; and

(b) Two additional sets of respiratory protection equipment that—

(1) Are stowed in the wheelhouse; and

(2) Protects the wearer from the cargo vapor for at least 5 minutes.

§ 154.1410 Decontamination shower.

When Table 4 references this section, a vessel carrying the listed cargo must have a decontamination shower and an eye wash that—

(a) Are on the weatherdeck; and

(b) Have their location marked EMERGENCY SHOWER in letters—

(1) 7.6 cm (3 in.) high; and

(2) 5.1 cm (2 in.) wide.

§ 154.1415 Air compressor.

Each vessel must have an air compressor to recharge the bottles for the air-breathing apparatus.

§ 154.1420 Stretchers and equipment.

Each vessel must have—

(a) Two stretchers or wire baskets; and

(b) Equipment for lifting an injured person from a cargo tank, hold, or void space.

§ 154.1430 Equipment locker.

One of each item of equipment under §§ 154.1400 and 154.1420 must be stowed in a marked locker—

(a) On the open deck in or adjacent to the cargo area; or

(b) In the accommodation house, near to a door that opens onto the main deck.

§ 154.1435 Medical first aid guide.

Each vessel must have a copy of the *IMCO Medical First Aid Guide for Use in Accidents Involving Dangerous Goods*, printed by IMCO, London, U.K.

§ 154.1440 Antidotes.

Each vessel must have the antidotes prescribed in the *IMCO Medical First Aid Guide for Use in Accidents Involving Dangerous Goods*, printed by IMCO, London, U.K. for the cargoes being carried.

§ 154.1445 Lifesaving devices.

The design of the lifeboats and liferafts must allow for launching at the final angle of heel from the lower side of the vessel.

Subpart D—Special Design and Operating Requirements

§ 154.1700 Purpose.

This subpart prescribes design and operating requirements that are unique for certain cargoes regulated by this part.

§ 154.1702 Materials of construction.

When Table 4 references one of the following paragraphs in this section, the materials in the referenced paragraph must not be in components that contact the cargo liquid or vapor:

(a) Aluminum and aluminum bearing alloys.

(b) Copper and copper bearing alloys.

(c) Zinc or galvanized steel.

(d) Magnesium.

(e) Mercury.

(f) Acetylide forming materials, such as copper, silver, and mercury.

§ 154.1706 Independent tank type C.

The following cargoes must be carried in an independent tank type C that meets § 154.701(a):

(a) Ethylene oxide.

(b) Methyl bromide.

(c) Sulfur dioxide.

§ 154.1710 Exclusion of air from cargo tank vapor spaces.

When a vessel is carrying acetaldehyde, butadiene, ethylene oxide, or vinyl chloride, the master shall ensure that air is—

(a) Purged from the cargo tanks and associated piping before the cargo is loaded; and

(b) Excluded after the cargo is loaded by maintaining a positive pressure of at least 13.8 kPa gauge (2 psig) by—

(1) Introducing a gas that—

(i) Is not reactive;

(ii) Is not flammable; and

(iii) Does not contain more than 0.2% oxygen by volume; or

(2) Controlling the cargo temperature.

§ 154.1715 Moisture control.

When a vessel is carrying sulfur dioxide, the master shall ensure that—

(a) A cargo tank is dry before it is loaded with sulfur dioxide; and

(b) Air or inert gas admitted into a cargo tank carrying sulfur dioxide during discharging or tank breathing has a moisture content equal to or less than the moisture content of air with a dewpoint of −45° C (−49° F) at atmospheric pressure.

§ 154.1720 Indirect refrigeration.

A refrigeration system that is used to cool acetaldehyde, ethylene oxide, or methyl bromide, must be an indirect refrigeration system that does not use vapor compression.

§ 154.1725 Ethylene oxide.

(a) A vessel carrying ethylene oxide must—

(1) Have cargo piping, vent piping, and refrigeration equipment that have no connections to other systems;

(2) Have valves, flanges, fittings, and accessory equipment made of steel, stainless steel, except types 416 and 442, or other material specially approved by the Commandant (G–MHM);

(3) Have valve disk faces, and other wearing parts of valves made of stainless steel containing not less than 11% chromium;

(4) Have gaskets constructed of spirally wound stainless steel with teflon or other material specially approved by the Commandant (G–MHM);

(5) Not have asbestos, rubber, or cast iron components in the cargo containment system and piping;

(6) Not have threaded joints in cargo piping;

(7) Have a water spray system under § 154.1105 that protects the above deck cargo piping; and

(8) Have a nitrogen inerting system or on board nitrogen gas storage that can inert the vapor space of an ethylene oxide cargo tank for a period of 30 days under the condition of paragraph (e) of this section.

(b) Cargo hose used for ethylene oxide must—

(1) Be specially approved by the Commandant (G–MMT); and

(2) Be marked "For (Alkylene or Ethylene) Oxide Transfer Only."

(c) Ethylene oxide must be maintained at less than 30°C (86° F).

(d) Cargo tank relief valves for tanks containing ethylene oxide must be set at 539 kPa gauge (78.2 psig) or higher.

(e) The vapor space of a cargo tank carrying ethylene oxide must be maintained at a nitrogen concentration of 45% by volume.

(f) A vessel must have a method for jettisoning ethylene oxide that meets §§ 154.356 and 154.1872.

§ 154.1730 Ethylene oxide: Loading and off loading.

(a) The master shall ensure that before ethylene oxide is loaded into a cargo tank—

(1) The tank is thoroughly clean, dry, and free of rust;

(2) The hold spaces are inerted with an inert gas that meets § 154.1710(b)(1); and

(3) The cargo tank vapor space is inerted with nitrogen.

(b) Ethylene oxide must be off loaded by a deepwell pump or inert gas displacement.

(c) Ethylene oxide must not be carried in deck tanks.

§154.1735 Methyl acetylene-propadiene mixture.

(a) The composition of the methyl acetylene-propadiene mixture at loading must be within the following limits or specially approved by the Commandant (G–MHM):

(1) One composition is—

(i) Maximum methyl acetylene and propadiene molar ratio of 3 to 1;

(ii) Maximum combined concentration of methyl acetylene and propadiene of 65 mole percent;

(iii) Minimum combined concentration of propane, butane, and isobutane of 24 mole percent, of which at least one-third (on a molar basis) must be butanes and one-third propane; and

(iv) Maximum combined concentration of propylene and butadiene of 10 mole percent.

(2) A second composition is—

(i) Maximum methyl acetylene and propadiene combined concentration of 30 mole percent;

(ii) Maximum methyl acetylene concentration of 20 mole percent;

(iii) Maximum propadiene concentration of 20 mole percent;

(iv) Maximum propylene concentration of 45 mole percent;

(v) Maximum butadiene and butylenes combined concentration of 2 mole percent;

(vi) A minimum saturated C_4 hydrocarbon concentration of 4 mole percent; and

(vii) A minimum propane concentration of 25 mole percent.

(b) A vessel carrying a methyl acetylene-propadiene mixture must have a refrigeration system without vapor compression or have a refrigeration system with the following features:

(1) A vapor compressor that does not raise the temperature and pressure of the vapor above 60°C (140°F) and 1.72 MPa gauge (250 psig) during its operation and that does not allow vapor to stagnate in the compressor while it continues to run.

(2) Discharge piping from each compressor stage or each cylinder in the same stage of a reciprocating compressor that has—

(i) Two temperature actuated shutdown switches set to operate at 60° C (140° F) or less;

(ii) A pressure actuated shutdown switch set to operate at 1.72 MPa guage (250 psig) or less; and

(iii) A safety relief valve set to relieve 1.77 MPa guage (256 psig) or less.

(3) A relief valve that vents to a mast meeting § 154.805 and that does not relieve into the compressor suction line.

(4) An alarm that sounds in the cargo control station and in the wheelhouse when any of the high pressure or high temperature switches under paragraphs (b)(2)(i) and (b)(2)(ii) of this section operate.

(c) A vessel carrying a methyl acetylene-propadiene mixture must have separate cargo piping, vent piping, and refrigeration equipment for methyl acetylene-propadiene that are segregated from other cargo piping, vent piping and refrigeration equipment on the vessel.

§ 154.1740 Vinyl chloride: Inhibiting and inerting.

When a vessel is carrying vinyl chloride, the master shall ensure that—

(a) Section 154.1618 is met; or

(b) Section 154.1710 is met, and the oxygen content of inert gas is less than 0.1% by volume.

§ 154.1745 Vinyl chloride: Transferring operations.

A vessel carrying vinyl chloride must meet § 40.15–1 of this chapter.

§ 154.1750 Butadiene or vinyl chloride: Refrigeration system.

A refrigeration system for butadiene or vinyl chloride must not use vapor compression unless it—

(a) Avoids any stagnation points where uninhibited liquid can accumulate; or

(b) Has inhibited liquid from the cargo tank added to the vapor upstream of the condenser.

§ 154.1755 Nitrogen.

Except for deck tanks and their piping systems, cargo containment systems and piping systems carrying nitrogen must be specially approved by the Commandant (G–MMT).

§ 154.1760 Liquid ammonia.

The master shall ensure that no person sprays liquid ammonia into a cargo tank containing more than 8% oxygen by volume.

Subpart E—Operations

§ 154.1800 Special operating requirements under Part 35 of this chapter.

Each vessel must meet the requirements of Part 35 of this chapter except § 35.30–20.

§ 154.1801 Certificates, letters, and endorsements: U.S. flag vessels.

No person may operate a U.S. flag vessel unless the vessel has a Certificate of Inspection, issued under Subchapter D of this chapter, which is endorsed with the name of the cargo that it is allowed to carry.

§ 154.1802 Certificates, letters and endorsements: Foreign flag vessels.

(a) No person may operate on the navigable waters of the United States a foreign flag vessel, whose flag administration issues IMCO Certificates, unless the vessel has—

(1) An IMCO Certificate issued by the flag administration which is endorsed with the name of the cargo that it is allowed to carry, and a Letter of Compliance issued by the Coast Guard endorsed under this part with the name of the cargo that it is allowed to carry; or

(2) Special approval under §§ 154.12 or 154.153.

(b) No person may operate on the navigable waters of the United States a foreign flag vessel, whose flag administration does not issue IMCO Certificates, unless the vessel has—

(1) A Letter of Compliance issued by the Coast Guard endorsed under this part with the name of the cargo that is allowed to carry; or

(2) Special approval under §§ 154.12 or 154.153.

(c) No person may operate on the navigable waters of the United States a foreign flag vessel unless the vessel has onboard the following plans and information which except for the certificates under paragraph (c)(1), are in English:

(1) The vessel's Cargo Ship Safety Construction Certificate and Cargo Ship Safety Equipment Certificate issued under the International Convention for Safety of Life at Sea, 1960.

(2) A description and schematic plan of the arrangement for inerting cargo tanks, hold spaces, and interbarrier spaces.

(3) A description of the cargo tank gauging equipment.

(4) A description and instruction manual for the calibration of the cargo leak detector equipment.

(5) A schematic plan that shows the locations of leak detectors and sampling points.

(6) If the vessel carries methane, a description of the systems for cargo temperature and pressure control. (See §§ 154.703 through 154.709).

§ 154.1803 Expiration of letters of compliance.

A Letter of Compliance is valid for a period not exceeding two years after the date of the examination under § 154.150. The Coast Guard marks the expiration date on the Letter of Compliance.

§ 154.1804 Document posted in wheelhouse.

No person may operate a U.S. flag vessel unless the documents under § 154.1801 are under glass in a conspicuous place in the wheelhouse.

§ 154.1806 Regulations on board.

No person may operate a U.S. flag vessel unless a copy of this part and a copy of Part 35 of this chapter are on board.

§ 154.1808 Limitations in the endorsement.

No person may operate a vessel unless that person complies with all limitations in the endorsement on the vessel's Certificate of Inspection or Letter of Compliance.

§ 154.1809 Loading and stability manual.

(a) No person may operate a vessel unless that vessel has on board a loading and stability manual.

(b) The loading and stability manual must contain—

(1) Information that enables the master to load and ballast the vessel while keeping structural stresses within design limits and positive metacentric height;

(2) Damage stability information, including all loading restrictions; and

(3) Trim information.

§ 154.1810 Cargo manual.

(a) No person may operate a foreign flag vessel, whose flag administration does not issue IMCO Certificates, on the navigable waters of the United States, or a U.S. flag vessel, unless the vessel has on board a cargo manual containing the information:

(1) A description of each cargo carried, its handling hazards as a liquid or as a gas including frostbite or asphyxiation, its safety equipment and necessary first aid measures required by this part.

(2) A description of the dangers of asphyxiation from the inerting gases used on the vessel.

(3) The measures that mitigate embrittlement of steel structure in way of cargo leakage.

(4) The use of the firefighting systems on the vessel.

(5) The features of the cargo containment system that affect its operation and maintenance, including pressure and temperature ranges and relief valve settings.

(6) Pressures, temperatures, and liquid levels for all operations.

(7) General information derived from the first loading of the vessel.

(8) Alarm settings.

(9) Descriptions of the components of the cargo system, including the following:

(i) Liquid cargo system.

(ii) Liquid recirculating or condensate return system.

(iii) Cargo tank cool-down system.

(iv) Cargo tank warm-up or vaporization system.

(v) Gas main system.

(vi) Cargo tank or compressor relief system and blocked liquid or gas relief system.

(vii) Inerting system.

(viii) Boil-off gas compressor or reliquefaction system.

(ix) Gas detection systems.

(x) Alarm or safety indication systems.

(xi) Cargo jettisoning system.

(xii) The system for using boil-off gas as fuel.

(10) A description of cargo loading and discharge operations, including simultaneous handling of multigrades of cargo and ballast.

(11) A description of cargo operations during the voyage.

(12) A description of cargo tank cool-down and warm-up operations including purging with inert gas and air.

(13) A description of hull and cargo tank temperature monitoring systems.

(14) A description of gas detection systems and alarm or safety systems.

(15) A description of the following conditions and their symptoms, including emergency measures and corrective actions:

(i) Cargo or ballast valve malfunction.

(ii) Low cargo tank gas pressure.

(iii) High fill level shutdown.

(iv) Gas compressor shutdown.

(v) Hull cold spots.

(vi) Cargo piping leaks.

(vii) Primary or secondary barrier failure.

(viii) Hold boundary structural failure.

(ix) Fire in vent mast head.

(x) Reliquefaction plant failure.

(xi) Vaporizer malfunction or failure.

(xii) Piping or cargo valve freeze-up.

(16) Any other matters relating to operation of the cargo systems.

(17) The operational means to maintain the vessel in a condition of positive stability in accordance with the loading and stability manual under § 154.1809 through all conditions of—

(i) Loading and deballasting; and

(ii) Unloading and ballasting.

(b) The master shall ensure that the cargo manual is kept up-to-date.

§ 154.1812 Operational information for terminal personnel.

The master shall ensure that terminal personnel are told the operational information required by § 154.1810(a)(17).

§ 154.1814 Cargo information cards.

(a) No person may operate a vessel unless a cargo information card for each cargo being transported is carried either in the wheelhouse, in the ship's office, or in another location easily accessible to the person in charge of the watch.

(b) When a vessel is moored at a terminal, the master shall ensure that a set of information cards is in the possession of the terminal's person in charge of cargo transfer operations.

(c) Each card must be at least 17 cm x 24 cm (6¾ in. x 9½ in.), have printing on one side only, and must contain the following information about the cargo:

(1) Name as listed in Table 4.

(2) Appearance.

(3) Odor.

(4) Safe handling procedures, including special handling instructions, and handling hazards.

(5) Procedures to follow in the event of spills, leaks, or uncontrolled cargo release.

(6) Procedures to be followed if a person is exposed to the cargo.

(7) Firefighting procedures and materials.

§ 154.1816 Cargo location plan.

The master shall ensure that—

(a) A cargo location plan is prepared that gives—

(1) The location and number of each cargo tank; and

(2) The name of the cargo in each tank;

(b) One cargo location plan is kept with the sets of cargo information cards required under § 154.1814; and

(c) The cargo names in the cargo location plan do not differ from the names of the cargoes listed in Table 4.

§ 154.1818 Certification of inhibition.

(a) Except as provided in § 154.1740(b), no person may operate a vessel carrying butadiene or vinyl chloride without carrying in the wheelhouse written certification from the shipper that the product is inhibited.

(b) The certification required by this section must contain the following information:

(1) The name and concentration of the inhibitor.

(2) The date the inhibitor was added.

(3) The expected duration of the inhibitor's effectiveness.

(4) Any temperature limitations qualifying the inhibitor's effective lifetime.

(5) The action to be taken if the time of the voyage exceeds the inhibitor's lifetime.

§ 154.1820 Shipping document.

No person may operate a vessel without carrying a shipping document in the wheelhoue that lists for each cargo on board—

(a) The cargo tank in which the cargo is stowed;

(b) The name of the shipper;

(c) The location of the loading terminal;

(d) The cargo name as listed in Table 4; and

(e) The approximate quantity of the cargo.

§ 154.1822 Shipping document: copy for transfer terminal.

While a vessel is moored at a transfer terminal, the master shall ensure that at least one copy of the shipping document is given to the terminal's person in charge of cargo transfer.

§ 154.1824 Obstruction of pumproom ladderways.

The master shall ensure that each cargo pumproom access is unobstructed.

§ 154.1826 Opening of cargo tanks and cargo sampling.

(a) The master shall ensure that each cargo tank opening is fully closed at all times.

(b) The master may authorize the opening of a cargo tank—

(1) During tank cleaning; and

(2) To sample a cargo that Table 4 allows to be carried in a containment system having a restricted gauging system if—

(i) The cargo tank is not being filled during sampling;

(ii) The vent system has relieved any pressure in the tank; and

(iii) The person sampling the cargo wears protective clothing.

(c) The master shall ensure that cargoes requiring closed gauging as listed in Table 4 are sampled only through the controlled sampling arrangement of the cargo tank.

§ 154.1828 Spaces containing cargo vapor: entry.

(a) No person may enter a cargo handling space without the permission of the master or without following a safety procedure established by the master.

(b) Before allowing anyone to enter a cargo handling space, the master shall ensure that—

(1) The space is free of toxic vapors and has an oxygen concentration of at least 19.5 percent oxygen by volume; or

(2) Those entering the space wear protective equipment with breathing apparatus and an officer closely supervises the entire operation in the space.

§ 154.1830 Warning sign.

(a) The master shall ensure that a vessel transferring cargo, while fast to a dock or while at anchor in port, displays a warning sign—

(1) At the gangway facing the shore so that the sign may be seen from the shore; and

(2) Facing outboard towards the water so that the sign may be seen from the water.

(b) Except as provided in paragraph (e) of this section, each warning sign must have the following words:

(1) Warning.

(2) Dangerous Cargo.

(3) No Visitors.

(4) No Smoking.

(5) No Open Lights.

(c) Each letter in the words on the sign must—

(1) Be block style;

(2) Be black on a white background;

(3) Be 7.6 cm (3 in.) high;

(4) Be 5.1 cm (2 in.) wide, except for "M" and "W" which must be 7.6 cm (3 in.) wide, and the letter "I" which may be 1.3 cm (½ in.) wide; and

(5) Have 1.3 cm (½ in.) stroke width.

(d) The spacing between letters must be—

(1) 1.3 cm (½ in.) between letters of the same word on the sign;

(2) 5.1 cm (2 in.) between words;

(3) 5.1 cm (2 in.) between lines; and

(4) 5.1 cm (2 in.) at the borders of the sign.

(e) The words "No Smoking" and "No Open Lights" may be omitted when the cargoes on board a vessel are not flammable.

(f) When a vessel carries or transfers vinyl chloride, the warning sign under paragraph (b) of this section must also have the words "Cancer Suspect Agent."

§ 154.1831 Person in charge of cargo transfer.

Before cargo transfer operations are started, the master shall designate the person in charge of cargo transfer.

§ 154.1832 Incompatible cargo.

(a) The person in charge of cargo transfer may not authorize the loading of incompatible[5] cargoes into cargo containment systems unless the cargo containment systems are separated by—

(1) Cofferdams, other than the spaces between primary and secondary barriers;

(2) Empty tanks;

(3) Tanks containing mutually compatible cargo; or

(4) Piping tunnels.

(b) The person in charge of cargo transfer may not authorize loading of incompatible [5] cargoes into cargo containment systems that have common piping or venting systems.

(c) The person in charge of cargo transfer may not authorize the loading into a tank of a cargo that is incompatible [5] with residue left in the tank from a previous cargo.

§ 154.1834 Cargo transfer piping.

The person in charge of cargo transfer shall ensure that cargo is transferred to or from a cargo tank only through the cargo piping system.

§ 154.1836 Vapor venting as a means of cargo tank pressure and temperature control.

When the vessel is on the navigable waters of the United States, the master shall ensure that the cargo pressure and temperature control system under §§ 154.701 through 154.709 is operating and that venting of cargo is unnecessary to maintain cargo temperature and pressure control, except under emergency conditions.

§ 154.1838 Discharge by gas pressurization.

The person in charge of cargo transfer may not authorize cargo discharge by gas pressurization unless—

(a) The tank to be offloaded is an independent tank type B or C;

(b) The pressurizing medium is the cargo vapor or a nonflammable, nontoxic gas that is inert with the cargo; and

(c) The pressurizing line has—

(1) A pressure reducing valve that has a setting that is 90 percent or less of the tank's relief valve setting; and

(2) A manual control valve between the pressure reducing valve and the tank.

§ 154.1840 Protective clothing.

The person in charge of cargo transfer shall ensure that each person involved in a cargo transfer operation, except those assigned to gas-safe cargo control rooms, wears protective clothing.

§ 154.1842 Cargo system: controls and alarms.

The master shall ensure that the cargo emergency shut-down system and the alarms under § 154.1325 are tested and working before cargo is transferred.

§ 154.1844 Cargo tanks: filling limits.

(a) Unless a higher limit is specified on the certificate the master shall ensure that a cargo tank is not loaded—

(1) More than 98 percent liquid full; or

(2) In excess of the volume determined under the following formula:

$$V_L = (0.98\ V)\left(\frac{d_T}{d_L}\right)$$

where:

V_L = maximum volume to which the tank may be loaded;

V = volume of the tank;

d_T = density at the reference temperature specified in paragraph (b) of this section; and

d_L = density of the cargo at the loading temperature and pressure.

(b) The reference temperature to be used in paragraph (a)(2) of this section is the temperature corresponding to the vapor pressure of the cargo at the set pressure of the pressure relief valves.

§ 154.1846 Relief valves: changing set pressure.

The master shall—

(a) Supervise the changing of the set pressure of relief valves under § 154.802(b);

(b) Enter the change of set pressure in the vessel's log; and

(c) Ensure that a sign showing the set pressure is posted—

(1) In the cargo control room or station; and

(2) At each relief valve.

§ 154.1848 Inerting.

(a) The master shall ensure that—

(1) Hold and interbarrier spaces on a vessel with full secondary barriers are inerted so that the oxygen concentration is 8 percent or less by volume when flammable cargoes are carried;

[5] Incompatible cargoes are listed in the compatibility guide entitled *Bulk Liquid Cargoes: Guide to Compatibility of Chemicals*. This circular is available from the Commandant (G-MHM-3/83), U.S. Coast Guard, Washington, D.C. 20590.

(2) Hold and interbarrier spaces contain only dry air or inert gas on—

(i) A vessel with partial secondary barriers;

(ii) A vessel with full secondary barriers when non-flammable cargoes are carried; and

(iii) A vessel with refrigerated independent tanks type C;

(3) When cargo tanks containing flammable vapor are to be gas freed, the flammable vapors are purged from the tank by inert gas before air is admitted; and

(4) When gas free cargo tanks are to be filled with a flammable cargo, air is purged from the tank by inert gas until the oxygen concentration in the tank is 8 percent or less by volume before cargo liquid or vapor is introduced.

(b) Inert gas must be supplied from the shore or from the vessel's inert gas system.

§ 154.1850 Entering cargo handling spaces.

(a) The master shall ensure that the ventilation system under § 154.1200 is in operation for 30 minutes before a person enters one of the following:

(1) Spaces containing cargo pumps, compressors, and compressor motors.

(2) Gas-dangerous cargo control spaces.

(3) Other spaces containing cargo handling equipment.

(b) The master shall ensure that a warning sign listing the requirement for use of the ventilation system, is posted outside of each space under paragraph (a) of this section.

(c) The master shall ensure that no sources of ignition are put in a cargo handling space on a vessel carrying flammable cargo unless the space is gas free.

§ 154.1852 Air breathing equipment.

(a) The master shall ensure that a licensed officer inspects the compressed air breathing equipment at least once each month.

(b) The master shall enter in the vessel's log a record of the inspection required under paragraph (a) of this section that includes—

(1) The date of the inspection; and

(2) The condition of the equipment at the time of the inspection.

§ 154.1854 Methane (LNG) as fuel.

(a) If methane (LNG) vapors are used as fuel in the main propulsion system of a vessel, the master shall ensure that the fuel oil fired pilot under § 154.705(c) is used when the vessel is on the navigable waters of the United States.

(b) When the methane (LNG) fuel supply is shut down due to loss of ventilation or detection of gas, the master shall ensure that the methane (LNG) fuel supply is not used until the leak or other cause of the shutdown is found and corrected.

(c) The master shall ensure that the required procedure under paragraph (b) of this section is posted in the main machinery space.

(d) The master shall ensure that the oxygen concentration in the annular space of the fuel line under § 154.706(a)(1) is 8% or less by volume before methane (LNG) vapors are admitted to the fuel line.

§ 154.1858 Cargo hose.

The person in charge of cargo transfer shall ensure that cargo hose used for cargo transfer service meets §§ 154.552 through 154.562.

§ 154.1860 Integral tanks: cargo colder than −10° C (14° F).

The master shall ensure that an integral tank does not carry a cargo colder than −10° C (14° F) unless that carriage is specially approved by the Commandant (G–MMT).

§ 154.1862 Posting of speed reduction.

If a speed reduction is specially approved by the Commandant under § 154.409, the master shall ensure that the speed reduction is posted in the wheelhouse.

§ 154.1864 Vessel speed within speed reduction.

The master shall ensure that the speed of the vessel is not greater than the posted speed reduction.

§ 154.1866 Cargo hose connection: Transferring cargo.

No person may transfer cargo through a cargo hose connection unless the connection has the remotely controlled quick closing shut off valve required under § 154.538.

§ 154.1868 Portable blowers in personnel access openings.

The master shall ensure that a portable blower in a personnel access opening does not reduce the area of the opening so that it does not meet § 154.340.

§ 154.1870 Bow and stern loading.

(a) When the bow or stern loading piping is not in use, the master shall lock closed the shut-off valves under § 154.355(a)(4) or remove the spool piece under § 154.355(a)(4).

(b) The person in charge of cargo transfer shall ensure that after the bow or stern loading piping is used it is purged of cargo vapors with inert gas.

(c) The person in charge of cargo transfer shall ensure that entrances, forced or natural ventilation intakes, exhausts, and other openings to any deck house alongside the bow or stern loading piping are closed when this piping is in use.

(d) The person in charge of cargo transfer shall ensure that bow or stern loading piping installed in the area of the accommodation, service, or control space is not used for transfer of the following:

(1) Acetaldehyde.
(2) Ammonia, anhydrous.
(3) Dimethylamine.
(4) Ethylamine.
(5) Ethyl Chloride.
(6) Methyl Chloride.
(7) Vinyl Chloride.

§ 154.1872 Cargo emergency jettisoning.

(a) The master shall ensure that emergency jettisoning piping under § 154.356, except bow and stern loading and discharging piping, is only used when an emergency exists.

(b) Emergency jettisoning piping when being used may be outside of the transverse tank location under § 154.310.

(c) The master shall ensure that cargo is not jettisoned in a U.S. port.

(d) When ethylene oxide is carried, the master shall ensure that the emergency jettisoning piping with associated pumps and fittings is on-line and ready for use for an emergency.

(e) The master shall lock closed the shut-off valves under § 154.356 when the emergency jettisoning piping is not in use.

(f) The person in charge of cargo transfer shall ensure that after the emergency jettisoning piping is used it is purged of cargo vapors with inert gas.

(g) The person in charge of cargo transfer shall ensure that entrances, forced or natural ventilation intakes, exhausts, and other openings to accommodation, service, or control spaces facing the emergency jettisoning piping area and alongside the emergency jettisoning piping are closed when this piping is in use.

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Table 4 - Summary of Minimum Requirements

CARGO NAME	SHIP TYPE	INDEPENDENT TANK TYPE C REQUIRED	CONTROL OF CARGO TANK VAPOR SPACE	VAPOR DETECTION (2)	GAUGING (3)	ELECTRICAL HAZARD CLASS AND GROUP	SPECIAL REQUIREMENTS		
ACETALDEHYDE	IIG/ IIPG	-	Inert	I & T	C	I - C	154.1400 (c) 154.1410	154.1710 154.1720	154.1870
AMMONIA, ANHYDROUS	IIG/ IIPG	-	-	T	C	I - D	154.1000 154.1400 (c)	154.1405 154.1410	154.1702 (b), (c),(e) 154.1760 154.1870
BUTADIENE	IIG/ IIPG	-	Inert	I	R	I - B	154.1702 (b), (d),(f) 154.1710	154.1750 154.1818	
BUTANE	IIG/ IIPG	-	-	I	R	I - D	NONE		
BUTYLENE	IIG/ IIPG	-	-	I	R	I - D	NONE		
DIMETHYLAMINE	IIG/ IIPG	-	-	I & T	C	I - C	154.1400 (c) 154.1405	154.1410 154.1702 (b), (c), (e)	154.1870
ETHANE	IIG	-	-	I	R	I - D	NONE		
ETHYLAMINE	IIG/ IIPG	-	-	I & T	C	I - C	154.1400 (c) 154.1405	154.1410 154.1702 (b), (c), (e)	154.1870
ETHYL CHLORIDE	IIG/ IIPG	-	-	I & T	R	I - D	154.1870		
ETHYLENE	IIG	-	-	I	R	I - C	NONE		

CARGO NAME	SHIP TYPE	INDEPENDENT TANK TYPE C REQUIRED	CONTROL OF CARGO TANK VAPOR SPACE	VAPOR DETECTION (2)	GAUGING (3)	ELECTRICAL HAZARD CLASS AND GROUP	SPECIAL REQUIREMENTS			
ETHYLENE OXIDE	IG	Yes	Inert	I & T	C	I - B	154.660(b)(3) 154.1400(c) 154.1405	154.1410 154.1702 (b), (d),(f) 154.1705	154.1710 154. 1720 154.1725	154.1730 154.1870(a),
METHANE (LNG)	IIG	-	-	I	C	I - D	154.703 through 154.709 154.1854			
METHYL ACETY-LENE-PROPADIENE MIXTURE	IIG/ IIPG	-	-	I	R	I	154.1735			
METHYL BROMIDE	IG	Yes	-	I & T	C	I - D	154.660 (b)(3) 154.1345 (c)(d) 154.1400 (c)	154.1405 154.1410 154.1702(a),(d)	154.1705 154.1720 154.1870(a), (b)	
METHYL CHLORIDE	IIG/ IIPG	-	-	I & T	C	I - D	154.1702 (a) 154.1870			
NITROGEN	IIIG	-	-	O	C	-	154.1755			
PROPANE	IIG/ IIPG	-	-	I	R	I - D	NONE			
PROPYLENE	IIG/ IIPG	-	-	I	R	I - D	NONE			
REFRIGERANT	IIIG	-	-	-	R	-	NONE			

CARGO NAME	SHIP TYPE	INDEPENDENT TANK TYPE C REQUIRED	CONTROL OF CARGO TANK VAPOR SPACE	VAPOR DETECTION (2)	GAUGING (3)	ELECTRICAL HAZARD CLASS AND GROUP	SPECIAL REQUIREMENTS		
SULFUR DIOXIDE	IG	Yes	Dry	T	C	-	154.660 (b)(3) 154.1345 (c), (d) 154.1400 (c)	154.1405 154.1410 154.1705	154.1715 154.1720 154.1870(a), (b)
VINYL CHLORIDE	IIG/ IIPG	-	-	I & T	C	I - D	154.1405 154.1410 154.1702(a)(b)(d)(f)	154.1710 154.1740 154.1745	154.1750 154.1818 154.1830 (f) 154.1870

(1) Refrigerant gases include non-toxic, non-flammable gases such as:

dichlorodifluoromethane
dichloromonofluoromethane
dichlorotetrafluoroethane
monochlorodifluoromethane
monochlorotetrafluoroethane
monochlorotrifluoromethane

(2) As used in this column:
"I" stands for flammable vapor detection
"T" stands for toxic vapor detection
"O" stands for oxygen detection
See §§ 154.1345 thru 154.1360

(3) As used in this column:
"C" stands for closed gauging

"R" stands for restricted gauging
See § 154.1300

(4) The designations used in this column are from the National Electrical Code.

Appendix A—Equivalent Stress

I. Equivalent stress (σc) is calculated by the following formula or another formula specially approved by the Commandant (G–MMT) as equivalent to the following:

$$\sigma_c = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x\sigma_y + 3\tau_{xy}^2}$$

Where:

σ_x = total normal stress in "x" direction.

σ_y = total normal stress in "y" direction.

τ_{xy} = total shear stress in "xy" plane.

II. When the static and dynamic stresses are calculated separately, the total stresses in paragraph I are calculated from the following formulae or another formulae specially approved by the Commandant (G–MMT) as equivalent to the following:

$$\sigma_x = \sigma_{x(\text{static})} \pm \sqrt{\Sigma(\sigma_{x(\text{dynamic})})^2}$$

$$\sigma_y = \sigma_{y(\text{static})} \pm \sqrt{\Sigma(\sigma_{y(\text{dynamic})})^2}$$

$$\tau_{xy} = \tau_{xy(\text{static})} \pm \sqrt{\Sigma(\tau_{xy(\text{dynamic})})^2}$$

III. Each dynamic and static stress is determined from its acceleration component and its hull strain component from hull deflection and torsion.

Appendix B—Stress Analyses Definitions

The following are the standard definitions of stresses for the analysis of an independent tank type B:

"Normal stress" means the component of stress normal to the plane of reference.

"Membrane stress" means the component of normal stress that is uniformly distributed and equal to the average value of the stress across the thickness of the section under consideration.

"Bending stress" means the variable stress across the thickness of the section under consideration, after the subtraction of the membrane stress.

"Shear stress" means the component of the stress acting in the plane of reference.

"Primary stress" means the stress produced by the imposed loading that is necessary to balance the external forces and moments. (The basic characteristic of a primary stress is that it is not self-limiting. Primary stresses that considerably exceed the yield strength result in failure or at least in gross deformations.)

"Primary general membrane stress" means the primary membrane stress that is so distributed in the structure that no redistribution of load occurs as a result of yielding.

"Primary local membrane stress" means the resulting stress from both a membrane stress, caused by pressure or other mechanical loading, and a primary or a discontinuity effect that produces excessive distortion in the transfer of loads to other portions of the structure. (The resulting stress is a primary local membrane stress although it has some characteristics of a secondary stress.) A stress region is local if—

$$S_1 \leq 0.5\sqrt{Rt}; \text{ and}$$

$$S_2 \leq 2.5\sqrt{Rt}$$

Where:

S_1 = distance in the meridional direction over which the equivalent stress exceeds 1.1 f.

S_2 = distance in the meridional direction to another region where the limits for primary general membrane stress are exceeded.

R = mean radius of the vessel.

t = wall thickness of the vessel at the location where the primary general membrane stress limit is exceeded.

f = allowable primary general membrane stress.

"Secondary stress" means a normal stress or shear stress caused by constraints of adjacent parts or by self-constraint of a structure. The basic characteristic of a secondary stress is that it is self-limiting. Local yielding and minor distortions can satisfy the conditions that cause the stress to occur.

(92 Stat. 1480 (Port and Tanker Safety Act of 1978, 46 U.S.C. 391a); 49 CFR 1.46(n)(4))

Dated: April 25, 1979.

J. B. Hayes,

Admiral, U.S. Coast Guard Commandant.

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